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THE AGRICULTURAL JOURNAL OF BRITISH EAST AFRICA, VOL. 1, 1908

The *Agricultural Journal of British East Africa* was first published in 1908, and ran until the outbreak of the First World War. Previously the East African Agricultural and Horticultural Society had published a journal, but the Kenya Agricultural Department was asked to publish a journal of agriculture in its place.

The first volume contains much evidence of energy and enterprise in agricultural development even in what are now referred to as the early days of Kenya. An article on Black Wattle gives information from Natal on the climate required and the methods of sowing, thinning and cropping, and on the prices ruling in Natal. To quote from the article "The planting of Black Wattle in British East Africa can at present be looked upon as an experiment only. At best it is a climatic exotic here, its success depending on *altitude compensating latitude* and herein is a serious element of doubt . . . Black Wattle has been planted for five years in British East Africa and the growth, up to the present, is generally good. The different varieties are growing so far with equal vigour. It is stated that a sample of bark from the oldest trees at Nakuru has lately been sent to Natal and given a good analysis of bark".

Although the sisal industry was still in its infancy it is stated that "The establishment of a sisal industry at the coast and parts of the highlands of British East Africa is now assured. The coast lands are perhaps the most favourable for such an industry, but it has been proved that sisal can be successfully grown as high as Nairobi and in the country between the latter place and Fort Hall, the yield of fibre being good and of excellent quality".

The first sisal plants were introduced from German East Africa towards the end of 1903 by Mr. J. Ainsworth, and were planted in his garden at Nairobi. Some of the original plants were presented to the Agricultural Department in March, 1904, and were used to establish a plot at the Nairobi Experimental Farm. At first sight it seems curious that the next introductions were from the West Indies, but it is possible that the planters in German East Africa were not willing to supply planting material for a rival sisal industry. Thus, in November, 1904, 1,500 bulbils were imported by the Agricultural Department from St. Vincent, West Indies. "These plants were used to establish a plot at 'Merihini' in Rabai district in May, 1905, as well as another at Makindu a little later, and in April, 1906, a plot was also planted at the Kibos Experimental Farm. These various plots are all proving a success and are providing valuable source for the distribution of numerous suckers".

Whatever the reason for importing bulbils from the West Indies in 1904, there was no difficulty in obtaining planting material from German East Africa in 1907, as 375,000 bulbils were imported from there in that year.

In an article on arabica coffee it is stated that "Coffee is one of the most promising of the minor industries of the Highlands, particularly in the Kikuyu and Kyambu districts, where many fields of well-grown trees are now established and which prove beyond a doubt the suitability of the soil and climate conditions to the plant".

"This industry was first commenced in the highlands, at the St. Augustine's Mission, Kikuyu, in 1901, the seed having been obtained from Bourbon, and by means of seed obtained from these trees the various fields of coffee in the highlands have been mostly established. The area now under coffee is approximately estimated at 500 to 600 acres, which is being extended".

At that time the most extensive coffee plantation was that of Messrs. Felix and Favre, comprising about 160 acres at Ruaraka. It is pointed out in the article that they were "going in largely for manuring and during the past year applied a good dressing of farmyard manure to the greater part of their coffee trees with very beneficial results. They are also practising intensive cultivation and for some time to come do not intend to much further increase the present area under coffee at Ruaraka".

The state of the dairy industry of Kenya at that time can be judged from a plea by a Mombasa resident under the title "Butter and Eggs and a Pound of Cheese". He (or she) says "I would now ask whether the producers cannot do something to come to the assistance of the consumers at the Coast by supplying such modest articles of commerce as butter and eggs and cheese. I would only now make a modest request for a modest beginning, though there is no reason why if the matter were seriously taken up it should not in a few years expand into a large and profitable business".

Whether the Kenya Co-operative Creameries owe their existence to the Mombasa resident is a matter of doubt, but it seems probable that the pyrethrum industry owes its existence to Volume I of the Agricultural Journal of British East Africa. The following quotation is from an article by H. Powell, Chief, Economic Plants Division. "The garden chrysanthemum we have already got in East Africa: it is common wherever gardens are made. But what I believe we have not yet got, and what is as useful as the common chrysanthemum is ornamental, is *Chrysanthemum cinerarifolium*. Dried and ground, this furnishes pyrethrum powder, which seems as much a specific for jiggers as quinine for malaria. I have seen a man with a little tin of pyrethrum powder go through a district swarming with jiggers and not get one. There seems no reason why jiggers and pyrethrum should not exist side by side, the pest and its antidote, exactly as the nettle and the dock-leaf of the story books! Pyrethrum powder will banish not only jiggers but all other insect pests, and is thus an extremely useful thing in climates where insect pests are as bad as in Equatorial Africa. Consider the terrible human tick fever of Uganda. Compared to this, jiggers and even malaria are mild troubles! . . . A preparation known as pyrethrum oil is sold and is said to have been used with success against malaria mosquitoes and jiggers. I tried this in Uganda, but found it inferior to pyrethrum powder. But pyrethrum powder (like coffee) must be used fresh to be quite efficacious, hence the advantage of growing it oneself. *Chrysanthemum cinerarifolium* (the chrysanthemum that furnishes pyrethrum powder) can be seen growing in the Botanical Gardens at Cape Town and Durban, and its growth there appears to indicate that it would succeed as a garden plant on the Highlands of British East Africa".

On the lighter side we quote at some length an article by R. J. Stordy, Chief Veterinary Officer, entitled "Digestive Powers of the Ostrich". He rightly claims that among the many remarkable stories of the powers of digestion of the ostrich this one probably establishes a record.

"The ostrich in question was the property of Mr. S. Clarke, Nairobi Falls Estate. The bird was about one year old, in poor condition, had been ill for a considerable period, and died on 19th October. Mr. Clarke made a post-mortem examination on the bird, and on opening into the glandular stomach (proventriculus) several brass cartridge cases fell out. He immediately put the stomach in a basin and brought it to me for examination. I made an incision across the organ at the same time laying open the gizzard, and from the two compartments there were removed 111 brass cartridge cases and two .303 bullets. The cases were of all sizes and description. . . ." There follows a complete classification of them and the article goes on "Many of the cartridges were worn to the size of a pea, in four instances only the detonators were left, while others had been but recently swallowed; some had the flanges worn down level with the body of the cases and the majority of them were crushed, distorted and full of semi-fluid ingesta. A large quantity of brassy flakes were found intermixed with the contents of the stomach and gizzard. As the stomach and gizzard were the only organs which were brought to me for examination, I am unable to say what was the cause of death, but certainly the consumption of the cartridge cases was not responsible, as the bird had apparently fed well up to the time of death and the condition of the stomach and gizzard was normal; as, however, a large number of these birds have recently died from intestinal parasites, I would be inclined to attribute its death to the same cause, more especially as Mr. Clarke mentions having noticed a number of worms in the intestines".

THE DISTRIBUTION AND BREEDING BEHAVIOUR OF THE SUDAN DIOCH (QUELEA Q. AETHIOPICA) IN TANGANYIKA

By H. J. de S. Disney and J. W. Haylock, Department of Agriculture, Tanganyika Territory

(Received for publication on 15th December, 1955)

During the past two years we have investigated this species intensively and the following data constitute a preliminary and general account of our work, together with relevant citations of the findings of other naturalists.

The Sudan Dioch is easily separated from other weaver birds. In the breeding dress the male can be distinguished by the crimson bill, black face and throat, and straw-coloured head and underparts. The female has a yellow-white bill and is of a dull sparrow-like colour. The young birds are similar to females but have a grey-brown bill, which gradually turns red on leaving the nest. In the non-breeding plumage the males and females look alike and are of a nondescript sparrow-like colour with bright red beaks. The red bill is the diagnostic character from other *Quelea* species.

Ever since Europeans have recorded their travels in Africa, there have always been reported vast flocks of *Quelea*. Only recently, however, has the seriousness of the losses caused by these birds been recognized, because of the much larger acreages of small grained crops planted by farmers and the greater importance of foodstuffs. Previously the native was usually able to keep the birds off his small garden. Before the arrival of a benevolent Government (which he knew would feed him if his crop failed), the African had to keep them off or starve. This is the situation in Italian Somaliland to-day. (Williams, 1954).

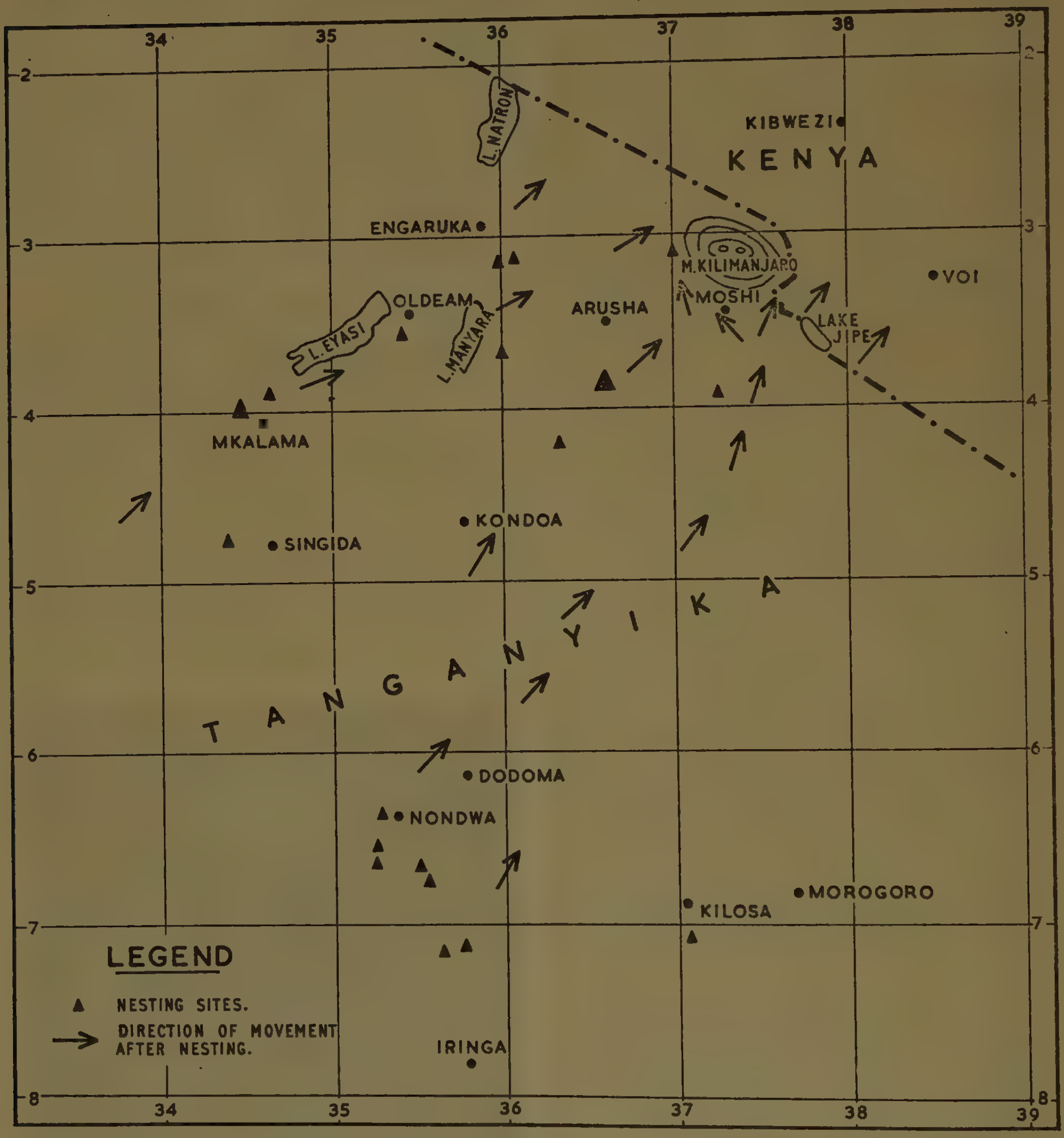
That the native did not always succeed is evident from the records of a *Quelea*-induced famine in Ugogo in 1881 (personal communication Mr. H. A. Fosbrooke). When Dr. Abbott was collecting birds by Taveta in 1888 he saw large flocks in September. In 1922 Arthur Loveridge reported a large flock that looked like a black cloud going to roost by the Sibiti River at Mkalama in October. This is where the first authentic large nesting site in Tanganyika was found in May, 1953.

Quelea swarms have often been compared to locusts and sometimes mistaken for them; in one case an experienced Locust Officer said he had never seen such vast numbers, and they even looked greater than locusts. At a camp in the bush the birds came into a tree in such vast numbers, and made so much noise, that the European there came out of his hut thinking a lorry was arriving.

Distribution and Movements

Our information suggests that in Tanganyika the Sudan Dioch lives in the country below the 30-in. rainfall isohyet. This agrees with data recorded from the Sudan and Senegal. The 30-in. isohyet encloses the whole of the Northern and Central Provinces of Tanganyika. This is also the area to which *Acacia mellifera* is practically confined in Tanganyika, although it follows this rain isohyet north into the Sudan. All the large nesting sites so far found in Tanganyika have been in this *Acacia*. In the Sudan the same *Acacia* is used as a nest site.

Fig. 1.—Discarded grain after the germ has been eaten.



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L. MANYARA
MKALAMA
KONDOA
SINGIDA
TANGANYIKA
DODOMA
NONDWA
KILOSA
MOROGORO
LEGEND
NESTING SITES.
DIRECTION OF MOVEMENT AFTER NESTING.
IRINGA

The main nesting area has not yet been found in Tanganyika. It would appear, however, to be in the south and west of Central Province. Breeding occurs in March and April. If the rains are good in Northern Province nesting may also take place in May and June. After nesting, the birds migrate east and north-east. Flocks of adult and young birds already move up from the south-west before breeding has begun in Northern Province. These migrate across to the Ruvu River and move north. They pause around the south side of Kilimanjaro, also about the remaining waterholes in Masailand. They wait here for the short rains to break in November and December in Southern Kenya—these rains often being better than the long rains there. The birds then move into Southern Kenya, and, if conditions are suitable, some may be in condition to come into full breeding and attempt to nest. Although some breeding occurs this short rain reproduction is rarely very successful. In February and March the birds move back into Tanganyika for the main breeding season.

Although this movement back and forth does take place, it does not seem possible that it can account for all the millions of birds present in Northern Province in September and October, in Masailand as well as round the south of Kilimanjaro during the same months. Further, the large migration seen passing north over the Ruaha River south of Dodoma in September, 1952, when breeding in this area should have taken place in March and all the birds to have moved north-east to south of Kilimanjaro long before September, cannot thus be accounted for. There are no physical (e.g. mountain) barriers, and it has been proved by ringing in Southern Rhodesia that the birds will travel at least 540 miles from Southern Rhodesia into Nyasaland where the ranges of *Quelea q. lathamii* and *Quelea q. æthiopica* overlap (Plowes, D. C. H., *in lit.*). Therefore there is no reason why these flocks should not range from the Sudan to South Africa, as they probably follow the rains. The complete answer will not be obtained until an international organization is set up to co-ordinate all information on movements and breeding.

The birds seem to remain in the dry areas as long as they can do so. In 1954, from August until the rains broke in December, there were many drinking at the few remaining waterholes in South Masailand. Birds were getting stuck in the mud by the thousand, so that the holes stank. Natives were knocking them down with sticks for food. The Diochs also stripped the leaves off the trees for food (*see* also Wilson, 1948). When the rains broke, very few birds were found in Masailand and Central Province, Tanganyika, but many were to be found in South Kenya. In other parts of Tanganyika the birds are seen only in small numbers in the dry season. Because of the two rainy seasons the movements in Tanganyika are probably more complicated than countries farther north and south.

Over 2,000 birds have been ringed with numbered bands, some of which are marked on the inside "Zoo, Pretoria", and others on the outside "Return Museum, Nairobi". It is hoped that finders will return these rings if possible, to the above addresses or direct to the Department of Agriculture, Dar es Salaam. In addition, ringed birds have been dyed with picric acid in 33 per cent alcohol. This is the only satisfactory dye so far found; the colour remains until the feathers are moulted. The only other successful dye is a proprietory hair dye, but this is much to expensive to use on a large scale, although it is very useful for the investigation of plumage changes in caged birds. So far there have been ringing returns only from where the birds were ringed near the wheatfields. One small flock of dyed birds was seen 20 miles south-east from Arusha, where they are ringed and dyed.

Damage to Crops

Great damage by these birds seems to occur in four-yearly cycles. Thus 1944, 1948, 1952 were bad years all over the Territory. It remains to be seen if 1956 will also be disastrous. The wheat farmers on Kilimanjaro suffered greatly in 1953, but there was no considerable damage over the rest of the Territory (or in Kenya), as there had been in the previous year. Kenya wheat suffered heavily in 1952, but not in 1953. This big attack on Kilimanjaro wheat can be correlated with the severe drought over the rest of the Northern Province for the second year in succession. This drought left no food for the birds in the drier and lower areas. The only green food was the wheat on West Kilimanjaro, and, as this is on the birds' normal migration route, they swarmed in and ate it up. At the same time these birds were only a small proportion of those actually present round the south of Kilimanjaro and Masailand. In 1954 there were good rains in Northern Province and

despite heavy breeding in May and June (even a few miles below the Kilimanjaro wheat-fields), no damage was caused until late September and October. The second invasion was seen to come from the south-west across the Ngaseri Plain to the Olmolog farms on north-west Kilimanjaro.

This year (1955), Northern Province and Masailand have again had little rain and no large-scale breeding has taken place. Nearly all the grass seed had already dried up and had been shed by June. The majority of the birds are young birds, with red bills, but some are only just starting to turn red. They have started to come into the wheat farms on West Kilimanjaro, even though many of these farms have little wheat due to drought and rust.

Fig. 2.—Nest of Sudan Dioch in Acacia mellifera.

We have evidence that the young bird will not eat hard wheat and will starve and die if fed only on hard seed. The young must have green grass seed or grain in the "milky" stage. The adults too prefer grass seed when they can get it; thus a large roost of mainly young birds may occur near sorghum or wheatfields (or even near native bulrush millet), yet provided there is green grass seed available little damage will be done to the crops. In Central Province where there were several nesting sites in March and April, 1955, little damage was reported after the young left the nest sites. The reason is that there was still grass seed available.

Thus it is obvious that damage to crops is closely related to rainfall, to grass seed availability in the cultivated areas at the time the crops are maturing, and to the age of the birds when they arrive.

Nesting Sites

As mentioned above, all large nesting sites so far found have been in *Acacia mellifera.* When nests are found in other bushes it will be found that the dominant bush is always *Acacia mellifera* and the nests in other bushes are an overflow and are very often not completed. Nesting sites covering a few acres to four square miles have been found. In March and April the birds nest in Central Province (Dodoma and Singida District) if the rains are sufficient. In the Nondwa District (west of Dodoma) the nests are often in *Acacia nigrescens* as well as *A. mellifera.*

If conditions are suitable large-scale nesting can also take place in May and June in Northern Province. This occurred in 1954, but not in 1955. This season the rain was very poor in the drier areas. Where there was rain it fell early and all the grass had dried up by May and June in the areas of *Acacia mellifera.* A small nesting site was found in May, 1955, at Engaruka, in the Rift Valley. The nests were in *A. nubica* and *A. tortilis,* there being only about two *A. mellifera* in the nesting site. This nesting could be correlated with the fact that this small area was the only place with suitable green grass with which the birds build their nests and feel the young. This small green strip was caused by water draining down from the Rift Wall. When the colony was first found it contained far more birds than eventually nested. There was plenty of *A. nubica* available. This perhaps suggests that they will not nest in large numbers except in *A. mellifera.*

There are incidentally two records of nesting in grass. A small number of birds nested with *Quelea erythrops* in bulrushes (*Typha* sp.) at Kilangali on the Mkata Plain near Kilosa in March, 1952 (Fuggles-Couchman, 1952). In January, 1954, half-completed nests were found in long grass by the Voi River in Kenya.

The nests are about the size of a man's fist and are built in bushes from 4–15 ft. high; from 50–200 or more nests may occur in a single bush. The bushes may be very scattered

(some 10–30 yards or more apart) or may grow as dense thickets difficult to walk through. The nests are round and firmly attached to several twigs or several grass or reed stems and do not hang, nor do they have a long spout or funnel like many other weavers. On one side of the nest there is an opening near the top which has a top lip which is bent over so that the bird enters from below. The nests are constructed from grass gathered near the site, and the nearby area is often completely stripped. The chief grass used is Star grass (*Cynodon plectostachyum*) which has long narrow leaves. Other grasses usually found at nesting sites are species of *Urochloa*, *Setaria* and *Brachiaria*, and these are used as food.

Nearly all the large nesting sites so far examined have shown zones of nests of different ages, at one end will be nests with eggs and at the other end half-grown nestlings. This may indicate that some birds start building and that others then see them nesting and join them.

There is some evidence of old nesting sites being used again. At a large site 40 miles south of Arusha some birds rebuilt old nests. At one apparently favourite place in the Rift Valley in June, 1954, there were nests of three ages, some black, others brown with broken eggs and fæces underneath, and a small area of ten bushes with nests with eggs, although these were later deserted. At Nondwa (Dodoma district) the birds nested in one place where they had previously nested in 1950. The old nests and bushes cut down by the natives were still visible. In Senegal there is also evidence of old nest-sites being used again (Dakar, 1954).

Nest Building and Reproduction

The nests are started by the males, who construct an upright ring of woven grass between twigs. At this stage they perch fluttering on the ring, endeavouring to attract the females. If successful, copulation takes place on the ring (Haylock, 1955). If the female does not accept, the male has to build again. Continual refusal by the females may explain the large number of half-built nests found or the abandonment of the site altogether, when broken and complete eggs can be found underneath the nests.

The eggs are laid is soon as the main structure has been completed, but when it is still thin enough for the eggs to be seen from outside. During incubation the male and female continue to add material and tidy the nest up, so that when the eggs are hatched the young are completely concealed. (Disney, 1955).

The eggs are 19 mm. by 13 mm. in size and are a pale greenish blue in colour with no markings. The usual number is three, sometimes two or four are laid and nests containing from one to seven eggs have been found.

Brooding is carried out by both the male and female by day, but at night only the female broods. Except for odd birds, the males roost elsewhere. After hatching, the female continues to brood at night, and in the evening as it gets cool the male is seen to brood the young. One male was seen repeatedly to come out anxiously to look for the female to relieve him so that he could go off to roost. When the nestlings are ten days old the female also roosts away from the site or outside the nest. She appears to return before the male arrives in the morning.

Fig. 3.—Nests in Acacia mellifera after bushes defoliated by DNOC aerial spraying.

The Young Bird

The young are fed as soon as hatched by regurgitation from the parent crop. They are chiefly fed on insects with a little grass seed. The insects are usually hard-bodied, such as grasshoppers (*Orthoptera*), beetles and weevils (*Coleoptera*) but also larvæ of *Lepidoptera*, frog-hoppers (*Hemiptera*) and termites (*Isoptera*). By the fifth day after hatching the crop

seems to come into use and the proportion of grass seeds to insects increases. By the time the young fly their food consists almost entirely of grass seeds. The adults also give the young grit. When the young have left the nest but before foraging on their own, they sometimes drop down to the ground underneath the bushes and pick up bits of eggshell.

The dependency of the young Diochs on protein food is characteristic of most species and is a powerful factor in the control of avian breeding seasons, even though there is yet no evidence that the seasonal advent of protein actually triggers reproduction (Marshall, 1951). At the same time it is certain that the Dioch can breed successfully only when insects are commonly available.

Even after they have left the nest and can fly the young are still fed by their parents at the nesting site. They do not leave the site until their throat feathers (the last to appear) are well grown.

When the young first leave the nest they roost beside it; later, when they can fly, they concentrate together at night, returning to their own bushes at dawn. They finally leave the nesting site to roost elsewhere some five days after climbing out of the nests.

The following incubation and fledgling periods were determined in May–June, 1954 in the Rift Valley, Northern Province:—

	Days
Nest building to first egg ..	8–9
Incubation	10
Hatching to flying	15
From flying to roosting away from nest bushes	5
Total ..	38–39

Observations in 1955 have confirmed these times except that the period between nest building and the appearance of the first egg may perhaps be only four days. (*See* also Wilson, 1948.)

Adults at the Nesting Site

Both the male and female are aggressive to other birds near their own nest. At four days old the young in one nest were observed being fed by their parents about once every 20 minutes between 1 p.m. and 5 p.m. The general time between feeds was 20 minutes, but sometimes when one parent had fed them, the other arrived only five minutes later. For about the first ten days the parents remove the droppings from the nest, but afterwards they are not removed and accumulate in the bottom of the nest. In general the birds go off in parties to get food, or they may join a party as it flies past. They again return in parties, leaving the group when they reach their own nest-bush. They do not appear to collect food beside the nest site, but go some distance for it. It was also noticed that in general the males and females go off in separate parties; one moment the nest-bush would be full of males, the next full of females.

The first recorded feeding of the young in the morning in June was at 6.45 a.m., and the last at 6.25 p.m. The adults arrived at the nesting site about 6.30 a.m. and the females usually came before the males.

Roosting and Flocking

The birds usually roost in tall grass or thick scrub of about 5–12 ft. high. When possible they seem to prefer tall grass (such as Elephant grass), or sedge and reeds in swamps. Roosts are usually near water so that the birds can drink before they leave in the morning and again when they return at night. In the evenings the birds first gather together in certain areas and then fly to the roost. They leave the feeding grounds in time to arrive in the last half-hour of daylight at the roost. Thus the time they leave the feeding grounds will give some indication on how far away is the roost. At 6,000 ft. on Kilimanjaro as the disc of the sun appears, they come out of the roost and sit on the edge of the bushes. Then when the disc is well clear of the horizon they all leave. At other places where it is not so cold, they start leaving about ten minutes before the disc appears and all have left by the time it is visible. In about ten minutes the roost is entirely empty.

By the wheatfields on West Kilimanjaro the roosts are usually in gullies and the bush is dense thickets of *Lippia* sage, *Lantana* and *Euclia* and large *Hibiscus* sp., some 8–10 ft. high. We have never found them roosting high up in trees.

Exactly where the adults go to roost away from the nesting sites is not clear. In one case it appeared that adults from two small nesting

sites were roosting in *Acacia mellifera* bush beside a larger nesting site which the owners had left. At Nondwa (Dodoma district) the males were seen to come into roost in grass in a waterhole with *Quelea cardinalis*, although before the light completely went most of the *Quelea q. æthiopica* had moved elsewhere. When spotting for roosts it is necessary to stay till the last of the light has gone, as the birds have a habit of slipping off somewhere else during the last glimmer of light.

Flocks examined attacking the wheat on West Kilimanjaro in 1953 consisted of a 50–50 sex ratio. Sometimes, especially after nesting, flocks may consist almost entirely of males. No other birds are seen in such vast flocks as these birds.

The birds will drink anywhere, but they prefer running water when available. When necessary they will drink on the wing even from vegetable garden sprays, but they usually land and go to the water's edge, or down a branch or grass stem, take a quick sip and immediately fly up again. They will also drink dew and raindrops.

Predators

The following animals prey on the Sudan Dioch:—

Aquila rapax (Tawny Eagle). When the young are about ten days old Tawny eagles appear, up to 20 being seen at once. The eagles alight in the bushes and pull down the *Quelea* nests and eat the young.

Leptotilos crumeniferus (Marabou Stork). These behave in the same way as the eagles, up to 20 being seen at a time. They have also been observed doing this in the Sudan. (Wilson, 1948.)

Rhamphiophis rostratus (Beaked or Sharp-nosed Snake). One of these snakes was seen in a bush eating the young.

Endoparasites Tape-worms have been found in both juvenile and adult birds.

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ARTHROPODS ASSOCIATED WITH STORED GROUNDNUTS IN NYASALAND

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Groundnut production is on the increase in Nyasaland. African cultivators use the kernels for food and as a cash crop. When ripe the groundnuts are harvested, sundried, and stored in the villages. They are stored in their pods in an undecorticated condition inside mudded bamboo storage containers which vary in shape and capacity. These storage containers stand on raised platforms about 12 to 14 in. above ground level. A vent, which is usually kept plugged with mud, exists near the base of the storage containers so that the groundnuts may be withdrawn by hand. In the villages the groundnut storage containers are usually placed beside those containing maize on the cob. The storage season commences during late March and early April, and continues through at least one year. During February and March of the current year, the author undertook an entomological survey of the groundnut storage containers in 50 different villages located in five separate production areas within the Central Province of the Protectorate. Old crop (1954) groundnuts only were examined, which had been stored for nearly a year under typical African storage conditions. The survey procedure adopted was first to obtain sanction from the village headman to examine a specific quantity of groundnuts from each container. For convenience, the measure employed was a local basket commonly used in the villages for sieving or holding maize. This basket held roughly from 5 to 7 lb. of groundnuts. Each sample was spread out on the ground, or on a mat if available, and examined for the presence of insects and mites. From each sample eight handfuls were set aside for groundnut damage counts. All damaged pods were put into Kilner jars and taken back to the laboratory for dissection.

Arthropod Infestation

Insect and mite infestation were, without exception, confined to damaged groundnuts. Many of the kernels inside the broken or holed pods were found to be rancid and mouldy, and contained cockroach egg sacs and insect frass. It was noted that where the kernel had been consumed, the epidermis of the kernel remained untouched as if it were regarded as inedible. Considered as a whole, the insect and mite infestation was moderate but never heavy, yet at the same time it was of sufficient standing to maintain a focus of infestation liable to spread to new crop groundnuts if stored in the vicinity. Compared with stored maize, the carry-over of stored groundnuts from one season to another is, at present, negligible; but in the future if this carry-over is, for any reason, increased considerably, it may allow insect infestation to obtain a serious hold on groundnuts stored under village conditions.

Cross infestation by insects from maize storage containers was noted in some villages.

Species Present

Lepidoptera

Only the Phycitid moth *Ephestia cautella* (Wlk.) was taken regularly, mostly as larvæ and pupæ, throughout the areas surveyed. This appears to be the most important lepidopterous pest of stored groundnuts. The larvæ feed on the kernel but not the pod, and spin up inside the pod where pupæ were frequently in evidence. Neither *Corcyra cephalonica* (Staint.) nor *Plodia interpunctella* (Hb.) were found amongst stored groundnuts throughout the survey. The latter has been found in stored maize in the lake-shore area within the Protectorate.

The Gelechiid moth *Sititroga cerealella* (Ol.) was taken on several occasions as dead adults, and had obviously come from adjacent maize storage containers where adults were noted in flight.

An Agrotid moth, possibly a species of the genus *Centrarthra* is of some interest as the larvæ appear to make use of the groundnut pods as a surface on which to spin up prior to pupation. No evidence was obtainable, however, as to whether or not the larvæ actually feed on the stored groundnuts during their development.

Coleoptera

Not all beetles found associated with stored groundnuts were considered pests. *C. oryzæ* (L.) was collected on several occasions, but is

known to be unable to attack groundnuts. It is a typical pest of grain in Nyasaland and elsewhere. The two most important beetles attacking groundnuts belonged to the Tenebrionid family. They were *Tribolium castaneum* (Hbst.) and *Gnathocerus cornutus* (F.). The former was easily the more numerous of the two, all stages being present inside damaged groundnuts. Larvæ as well as adults of *G. cornutus* were taken, but not a single individual of the closely allied species *G. maxillosus*, although it is known to be one of the more important secondary pests of stored maize in Nyasaland (Salmond 1955). Next in importance was the Cucujid *Oryzæphilus mercator* (Fauv.). Howe (1953) records that in commercial storage oilseeds are generally infested by *O. mercator* and cereal produce by *O. surinamensis* (L.). The author's findings in respect of groundnuts in Nyasaland uphold this statement. Two other members of the Cucujid family were collected; *Ahasverus advena* (Waltl.) and *Læmophloeus minutus* (Oliv.). The former was found on groundnuts which showed a high degree of rancidity and mouldiness. It is considered a mould feeder by Hinton and Corbet (1943). *Læmophloeus minutus* was collected twice only in adult form.

In addition, single adults of the following families were collected:—

Nitidulidæ.—*Carpophilus hemipterus* (L.).
Carpophilus dimidiatus (F.).

Lathridiidæ.—*Cartodere* sp. (not in the British Museum collection).

Coleopterous larvæ belonging to the family Dermestidæ were found in the form of one specimen of *Attagenus* sp. perhaps *piceus* (Ol.) and two of *Trogederma* sp. perhaps *T. granarium* (Everts). The latter is of considerable interest as it has not previously been collected by the author in any locally stored produce so far examined. The only previous record of its presence in Nyasaland appears to be that by Breese (1950) who records it on maize from the Argentine imported in the year of the famine (i.e. 1949). The author has collected it on stored beans in Northern Rhodesia. In Northern Nigeria, Cotterell *et al* (1952) record it as a major pest of groundnuts whilst Darling (1951) lists it as one of the major pests of sorghum in the Sudan. Recently in the Western areas in U.S.A. a determined effort has been made with methyl bromide fumigation to eradicate it in produce warehouses (Agric. and Food Chemistry, 1955). A careful watch for adults and larvæ should be maintained in large bulks of stored groundnuts in Nyasaland.

Other Orders

Orthoptera was represented by nymphs and adults of the family Blattidæ. It was common to note cockroaches scuttling away from the baskets of stored groundnuts brought for examination by the women of the village. Hymenoptera adults were nearly always present but did not appear to have any real pest significance. They included the following:—

Formicidæ.—*Pheidole megacephala* Fab. spp. *punctulata* M.

Chalcididæ.—*Antrocephalus mahensis* Masi.

Braconidæ.—*Bracon* sp. too damaged for further determination.
Phanerotoma sp.

As termites cause particular and specific damage to groundnuts, they have been dealt with separately in the next section.

Arachnida

Three adult Chelifers were found. They have been identified as *Stenowithius ugandanus* (Beier). They appear to be predatory on early instar coleopterous and lepidopterous larvæ.

Mites were also collected in association with mouldy and insect infested groundnuts. The mites had little economic value but are worth recording:—

Cheyletidæ.—*Cheyletus munroi* (Hughes).

Tyroglyphidæ.—*Tyrophagus castellanii* (Hirst).
Acotyledon batsylevi (Zach.).

Parasitidæ.—*Zercoseius macauleyi* (Hughes).

Insect Damage in Stored Groundnuts

Insect damage associated with stored groundnuts may be conveniently grouped into two types of damage (*a*) that which occurs after ripening but before harvesting and (*b*) that which occurs during the actual storage period. The former is effected by termites and not as Hall (1954) states "By lepidopterous larvæ or larvæ and adults of the beetle *Tribolium castaneum*". The termites involved in Nyasaland belong, according to Sands (1955), to the subterranean fungus growing sub-family Macrotermitinæ. So far the following members

of this sub-family have been collected in groundnuts growing in the Central Province:—

Pseudacanthotermes militaris (Hagen).

Macrotermes bellicosus (Smeathman).

Odontotermes vulgaris (Haviland).

Odontotermes zambeziensis (Sjöstedt).

Odontotermes latericius (Haviland).

Ancistrotermes sp. near *latinotus* (Holmgren).

Allodontermes sp. near *schulzei* (Silvestri).

Odontotermes tanganicus (Sjöstedt).

The damage is very characteristic and referred to locally as "Kalanzi" damage. African peasants state that almost all of this damage is effected in the field and a very little, if any, occurs during the storage period in the villages. Termites were not collected from amongst stored groundnuts in the villages visited. The damage effected is as shown in Fig. I.

Fig. 1

The exocarp of the epidermis is removed exposing the reticulate structure of the underlying mesocarp. This damage is superficial only and does not permit the entry of stored products pests to the kernel within the pod.

As previously stated, eight handfuls of groundnuts were set aside from each sample examined and damage counts made of (1) the externally sound, undamaged groundnut pods, (2) the termite-damaged groundnut pods, and (3) the broken or holed groundnut pods in which insect infestation was often apparent. The results obtained were averaged for the five areas surveyed and tabulated in Table I.

TABLE I.—MEAN PERCENTAGE SOUND, AND DAMAGED GROUNDNUT PODS FOUND IN SAMPLES OF GROUNDNUTS EXAMINED IN FIVE SEPARATE DISTRICTS IN THE CENTRAL PROVINCE OF NYASALAND

District Concerned	(I) Sound groundnut pods	(II) Termite-damaged groundnut pods	(III) Broken or holed groundnut pods
	per cent	*per cent*	*per cent*
Fort Manning ..	66·60	20·64	12·76
Nambuma ..	72·57	19·36	8·07
Nsaru	60·32	32·37	7·31
Nathenje	78·94	13·89	7·17
Dedza and Ncheu	71·79	19·86	8·35

The hold obtained by pests such as *Tribolium castaneum* and *Ephestia cautella* appears to be largely governed by the extent to which pods are damaged by those harvesting them, and the number of damaged pods brought into store. From Table I it is seen that the amount of broken and holed pods ranges from 7 to 12 per cent. Few stored products pests are able to penetrate sound groundnut pods. An exception is *Careydon fuscus*, but this Bruchid has not as yet been recorded from Nyasaland as a pest of groundnuts. Both *Ephestia cautella* and *Tribolium castaneum* are frequently met with in the wild, and may well be introduced with the groundnuts. The majority of broken or holed pods were damaged at the stalk end of the pod. Careful detachment from the plant would pay dividends as far as insect infestation is concerned.

CONTROL MEASURES

It is of little use recommending at this stage expensive insecticides to African cultivators, but for their own benefit they have been advised to continue storing groundnuts in their pods; to reject as far as possible the storing of damaged or broken pods; to use up old crop groundnuts first; to store new crop groundnuts separately, and to add a sprinkling of sieved wood ash over the groundnuts as a precaution against the entry of flying insects.

As far as the local Produce Marketing Board are concerned, all groundnuts are purchased in a decorticated condition. The principal pests collected from shelled groundnuts in bags have been *Ephestia cautella* and *Tribolium castaneum*. These pests are also common to stored

maize so that it becomes important not to place unfumigated groundnuts beside fumigated maize and *vice versa*. It is normal practice in Nyasaland for shelled groundnuts stored in bags to be fumigated with methyl bromide at a dosage of 3½ lb. per 1,000 cu. ft. of space for an exposure period of 24 hours. This routine should be continued each year and care taken to avoid reinfestation by flying insects after fumigation by monthly spraying with 25 per cent Lindane at the rate of 20 mgm. per square foot of surface area over the stacks of groundnuts. In addition, a careful watch should be maintained by those in charge of storage sheds for the presence of *Trogoderma* adults or larvæ. Once this pest is well established it is most difficult to eradicate it completely.

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CHEMICAL FACTORS LIMITING GROWTH OF PHYTOPLANKTON IN LAKE VICTORIA

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The problem of phytoplankton production in tropical waters differs from its counterpart in temperate regions in several important respects. The higher temperature and stronger radiation that are usually found within the tropics are the primary factors responsible. It is well known that certain species of planktonic algæ are limited to cold water. The well-marked seasonal changes that occur in temperate latitudes afford an opportunity for the development of both stenothermal and eurythermal organisms at different times of the year in the same lake. There is a good deal of data available to show that fluctuations in the population of certain planktonic algæ are controlled by limiting concentrations of various chemical nutrients, e.g. phosphorus and nitrogen [2], silica [3]. However, Ruttner [1] in a recent review of limnological problems, states that the overall production of phytoplankton is usually limited by low temperature in temperate lakes although, in winter, light is frequently a limiting factor. Hutchinson's conclusions, from a study of phytoplankton growth in Linsey Pond [4], were that fluctuations in growth could not be explained merely in terms of chemical nutrient deficiencies. Riley has made several important observations on this subject. He showed that, on Georges Bank, plankton populations are at a minimum during the annual period of lowest radiation [5]. A theoretical analysis was also made by Riley *et al* of the seasonal changes in phytoplankton in Korean waters [6]. The conclusion reached, after a study of 450 samples taken during the period 1931–33 and the relevant meteorological data, was that nutrient salts determined the time, duration and magnitude of fluctuations in the phytoplankton population during the summer and autumn, but that the mid-winter minimum and the vernal burst of growth were controlled by radiation.

There is a formidable weight of evidence, therefore, showing that change in population of phytoplankton is controlled largely by climatic conditions and that nutrient deficiencies may be a controlling factor only during relatively short periods.

These conclusions are restricted, however, to lakes and seas which experience large annual climatic variations. Within the tropics, water temperatures are high and uniform throughout the year, although minor fluctuations may occur.

Similarly, day length is uniform and the mid-day sun is always near the vertical, so providing maximum penetration of light into the water. Climatic conditions in the tropics are therefore unlikely to impose limits on production.

Investigations on the problem of phytoplankton productivity in the waters of Lake Victoria have been pursued since 1949. Observations from the shallow bays and inlets showed that no annual cycle of phytoplankton occurred. In view of the favourable climatic conditions found in this area, factors limiting growth of phytoplankton were sought in the form of deficiencies in chemical nutrients dissolved in the water.

Chemical analyses were made at frequent intervals to determine any changes in the concentration of the inorganic constituents of the water. Mackereth [7], discussing the utilization of phosphorus by *Asterionella*, concluded that water analyses could be of value by indicating those nutrients which are not limiting in concentration. Analyses of the water were therefore made at frequent intervals during 1950 and 1951. They showed the presence of silica at a concentration of 3–4 p.p.m. Phosphates and the inorganic compounds were usually found to be below the limit of detectability (i.e. 0.05 p.p.m. and 0.1 p.p.m. respectively in our system of analysis). However, the presence of these two salts was often recorded and therefore must be present, on such occasions, in amounts in excess of the requirements of the phytoplankton [8].

Positive evidence regarding limiting nutrients was sought, using the well-known method of adding various nutrients to lake water samples and observing changes in the phytoplankton population. Calcium, nitrogen and phosphorus

were tried singly and in various combinations. No increase in the growth of phytoplankton was observed. In fact, a sharp decrease in population was usually found. Further investigations showed that the experimental conditions introduced new factors, the effect of which appeared to mask that of nutrient change in the medium. More detailed experiments of this type in the laboratory were not possible because attempts to grow some of the more important planktonic algæ of Lake Victoria in artificial culture did not meet with success.

Agar cultures of *Chlorella*, a green alga, and of *Anabæna*, a blue-green alga, were then obtained from elsewhere. Members of these genera are common in the plankton of Lake Victoria and it was decided to use these cultures in some preliminary experiments. These experiments were devised to determine which nutrients were limiting the growth of phytoplankton in the lake water.

Methods

Pure bacteria-free cultures of *Chlorella pyrenoidosa* Chick and *Anabæna cylindrica* Lemm. were obtained from Dr. G. E. Fogg, University College, London. The wholly inorganic medium which was used in the experiments with these algæ had the following composition in the case of the *Anabæna* culture:—

Magnesium sulphate	0.2 gms.
Potassium phosphate	0.2 gms.
Calcium chloride	0.1 gms.
Ferrous sulphate	0.4 mgms. as Fe.
Ammonium molybdate	0.1 mgms. as Fe.
Boric acid	0.1 mgms. as B.
Manganese sulphate	0.1 mgms. as Mn.
Copper sulphate	0.01 mgms. as Cu.
Zinc sulphate	0.01 mgms. as Zn.
Pyrex distilled water	1 litre.

The same medium was used for *Chlorella* with the addition of:—

Potassium nitrate	0.5 gms.

200 c.c. of culture medium in a 250 c.c. Ehrlenmeyer flask were used in all experiments. The flasks were suspended on a wire framework attached to a window but out of the path of direct sunlight. Each was aerated continuously by a slow stream of filtered air.

All material and apparatus were sterilized by autoclaving at 15 lb. pressure for 15 minutes and the usual precautions were observed during assembly and inoculation to prevent bacterial contamination.

At the conclusion of each experiment, the state of the cultures was evaluated visually. Then the dryweight of the algæ in each flask was estimated, in the case of *Anabæna*, by filtering the medium through a paper (Green's Hyduro No. 995) and weighing the dried residue. The *Chlorella* proved difficult to filter and these cultures were centrifuged and the cells, thus separated, were dried on filter paper. Drying was carried out using a hot-air oven at a temperature of 110°C. In certain cases, the organic material, both dissolved and finely suspended, in the filtrate was estimated using acidified potassium permanganate.

Results

A preliminary experiment showed that good growth of the *Chlorella* and *Anabæna* was obtained in the inorganic culture medium but that there was negligible growth in lake water, even with the addition of calcium, phosphate or nitrate. Very dense cultures were obtained, however, using lake water enriched with the salts comprising the inorganic medium. While an enrichment of the lake water with the constituents of the inorganic medium both singly and in various combinations might have been the logical course of future investigations, it was decided that a better method would be to omit individual constituents from the fully enriched lake water. If any doubt arose that poor growth in any particular medium was caused by an experimental deficiency, then the replacement of the omitted constituent would prove the point. This safeguard on the deductions from the experimental results was deemed important.

Media were prepared consisting of lake water enriched with all the various constituents of the inorganic medium except one. It can be seen from the results in Table I, that the omission of calcium, iron, molybdenum, manganese, copper, boron and zinc salts had relatively little effect on the algal growth. Omission of magnesium sulphate, potassium phosphate or nitrate from the enrichment medium had a markedly adverse effect.

Cultures P and B were each divided into two parts. The first of each was supplied with magnesium chloride but no change was observed in the condition of the culture. The second was supplied with sodium sulphate and a vigorous growth of the algæ was obtained within a few days. It was concluded that the lake water contained adequate amounts of all the nutrients required for plant

growth with the exception of sulphate, phosphate, and, in the case of the non-nitrogen-fixing algæ, nitrate. Nine further experiments were completed using lake water collected at different times of the year from different parts of the lake and at different depths. The above conclusions were confirmed in all cases.

The effect of sulphate deficiency on the cultures was more marked than the dry weights indicate. Cultures deficient in sulphate were pale, and though growth continued to some extent, the lack of chlorophyll was obvious even to the most casual observer.

Table II shows again that the nutrients in least supply in the lake water are sulphate, phosphate and nitrate. The *Anabæna* culture No. 3 for instance gives almost as high a yield as culture No. 12 although only sulphate and phosphate had been added to the lake water. In this experiment, the nitrogen present in the lake water is insufficient to support more than a slight growth of *Chlorella.* However, *Chlorella* cultures 1–6 show that no marked increase in growth occurs unless phosphate is available. *Chlorella* cultures 7 and 10 show that a deficiency of either of these nutrients gives rise to the same amount of growth, far below that of the control. It may be seen, however, that the *Anabæna* cultures give a higher dry weight in the absence of phosphate than of sulphate (*Anabæna* 7 and 10).

On this occasion, therefore, it seemed that the most important nutrient deficiency in the lake water, as far as the nitrogen fixing algæ were concerned, was sulphate.

Sterility precautions were completely relaxed in one experiment (*see* Table III) in order to estimate the role, if any, of bacterial metabolism. It seems that the nitrogen supply is augmented under these conditions, for the yields of *Chlorella* were considerably higher than in the other experiments. Less reliance, however, can be placed on the dryweight figures, as bacteria and fungi, although not obvious, may have contributed to them. The comparison of these weights shows the importance of sulphate and phosphate (*see* cultures 6), and in the case of *Anabæna,* there is a greater effect shown by a sulphate as compared with a phosphate deficiency (cultures 2–5). The *Chlorella* cultures 4, 5, 7, 8 indicate a similar tendency.

Rodhe [2] described a successful method for the determination of iron in the waters of Lake Sharsjon using cultures of *Scenedesmus.* He concluded that this method is more sensitive than a purely chemical one but troublesome and time-consuming in operation. Reproducible results, even with the same culture, could not be obtained and so an accurate estimation of iron is only possible when a closely graded control series is grown together with the sample culture. An important advantage of the method is that only biologically available iron is measured. An attempt was made to see if a similar quantitative method could be used to evaluate the nutrient status in lake water. The experimental results are shown in Table IV.

Anabæna culture 5 shows that the addition of 0.2 mgms. $MgSO_4$ in 200 c.c. is insufficient to overcome sulphate as a primary limiting factor in the lake water. Extrapolation of the graph of the dryweights of *Anabæna* in cultures 2, 4 and 5 against the amount of sulphate added, indicates that a sulphate concentration of just over 1 p.p.m. is already present in the lake water. This result is of the same order as that found by purely chemical methods [8]. *Anabæna* cultures 9–12 show that the sulphate requirements must be met before a response to added phosphate is found. Increase of all other nutrients is clearly of minor importance to *Anabæna.* The *Chlorella* culture 9 shows that no growth of this alga is obtained unless nitrate is supplied. After nitrate, phosphate is indicated as the next nutrient in short supply in the lake water. (*Chlorella* cultures 16, 17.) The best growth is shown by culture 13 where sulphate, phosphate and nitrate are in adequate supply. All other mineral requirements of *Chlorella* are met by salts already present in the lake water.

Many accounts of culture methods of algæ have shown that natural waters frequently contain a growth-promoting substance which is not present in artificial media. Pringsheim [9], for instance, recommends the addition of soil solution to an artificial medium when cultivating certain algæ.

The experiments recorded in Table V show that *Anabæna* grows better in media made up with lake water than in media made up in distilled water. As it is unlikely that the distilled water contained any deleterious substances which might cause a reduction in the growth of *Anabæna,* one must conclude that the lake water contains some growth-promoting substances. (The experiments on the effect of these substances on the growth of *Chlorella*

TABLE I.—THE GROWTH OF CULTURES FROM 17–9–52 TO 23–10–52 IN LAKE OR DISTILLED WATER WITH VARIOUS INORGANIC ADDITIONS

Culture No.	Inoculum	Medium	Appreciation of growth	pH	At harvesting mgms. Dry weight
A	*Anabæna*	Lake water and all nutrients	Good	8·64	108
B	,,	Lake water and all nutrients except $MgSO_4$	Pale	—	—
C	,,	Lake water and all nutrients except K_2HPO_4	,,	—	—
D	,,	Lake water and all nutrients except $CaCl_2$	Good	9·46	313
E	,,	Lake water and all nutrients except Fe	,,	8·84	108
F	,,	Lake water and all nutrients except Mo	,,	9·1	106
G	,,	Lake water and all nutrients except Mn	,,	9·58	60
H	,,	Lake water and all nutrients except Cu	,,	9·38	55
I	,,	Lake water and all nutrients except B, Zn	,,	9·1	196
K	,,	Distilled water and all nutrients ..	Fair	8·31	1
L	,,	Lake water only	No growth	—	—
M	*Chlorella*	Lake water only	,,	—	—
N	,,	Distilled water and all nutrients ..	Slight growth	—	—
O	,,	Lake water and all nutrients	Good	—	—
P	,,	Lake water and all nutrients except $MgSO_4$	Pale	—	—
Q	,,	Lake water and all nutrients except Cu, B, Zn, Mn	Good	—	—

TABLE II.—THE GROWTH OF CULTURES FROM 17–9–53 TO 23–12–53 IN LAKE OR DISTILLED WATER WITH VARIOUS INORGANIC ADDITIONS

(*During the harvesting of the algæ in cultures No. 8 a small amount of material was lost. The dry weights recorded for these cultures is therefore slightly low*)

Culture No.	Salts added to Lake Water	Dry wt. in mgms. of *Anabæna* cultures	Additions for for *Chlorella* medium	Dry wt. in mgms. of *Chlorella* cultures
1	50 p.p.m. each of K_2HPO_4.. ..	2	Nil	Nil
2	50 p.p.m. each of $K_2HPO_4+Na_2SO_4$	43	,,	,,
3	50 p.p.m. each of $K_2HPO_4+MgSO_4$	57	,,	,,
4	50 p.p.m. each of $K_2HPO_4+CaCl_2$	18	,,	4
5	100 p.p.m. K_2HPO_4..	7	,,	10
6	Nil		,,	2
7	Complete medium except sulphate..	12	125 p.p.m. KNO_3	14
8	Complete medium except magnesium	61	,,	26
9	Complete medium except $CaCl_2$ ..	85	,,	46
10	Complete medium except K_2HPO_4	31	,,	13
11	Complete medium except KNO_3 ..		Nil	5
12	Complete medium	70	125 p.p.m. KNO_3	45
13	Complete medium made with distilled water	7	,,	30

TABLE III.—THE GROWTH OF CULTURES FROM 22–4–54 TO 10–11–54 IN A LAKE WATER MEDIUM

(No precautions were taken to avoid bacterial and fungal contamination)

Culture No.	Salts added to Lake water	Dry Wt. of Cultures in mgms. *Anabæna*	Dry Wt. of Cultures in mgms. *Chlorella*
1	All nutrients	100	102
2	All nutrients except $MgSO_4$	38	53
3	All nutrients except K_2HPO_4	63	35
4	$MgSO_4$	67	52
5	K_2HPO_4	57	77
6	$MgSO_4 + K_2HPO_4$	131	94
7	$KNO_3 + MgSO_4$		37
8	$KNO_3 + K_2HPO_4$		55

TABLE IV.—GROWTH OF ALGAL CULTURE, 6–2–54 TO 24–4–54 IN ENRICHED LAKE WATER

Culture No.	Salts added to Lake Water	Harvest in mgms. of *Anabæna* Cultures: Dry wt.	Residual organic matter	Total Production	Harvest in mgms. of *Chlorella* Cultures: Dry wt.	Residual organic matter	Total Production
1	Nil	22	1·7	23·7	2	Nil	2·0
2	$MgSO_4$ 20 mgms.	67·5	5·3	72·8	1	0·2	1·2
4	$MgSO_4$ 2 mgms.	55	7·6	62·6			
5	$MgSO_4$ 0·2 mgms.	34	3·5	37·5			
6	K_2HPO_4 20 mgms.	32	3·6	35·6	2	0·3	2·3
7	K_2HPO_4 5 mgms.	39	2·8	41·8			
8	K_2HPO_4 2 mgms.	40	2·8	42·8			
9	$MgSO_4$, K_2HPO_4 each 20 mgms.	72	11·9	83·9	2	Nil	2·0
10	$MgSO_4$. K_2HPO_4 each 5 mgms.	70	12·5	82·5			
11	$MgSO_4$, K_2HPO_4 each 2 mgms.	72	7·9	79·9			
12	$MgSO_4$, K_2HPO_4 each 0·2 mgms.	36	2·9	38·9			
13	$MgSO_4$, K_2HPO_4 each 20 mgms. and KNO_3 20 mgms.	68	12·8	80·8	21	4·0	25·0
14	Full medium	72	12·3	84·3	12	2·4	14·4
15	KNO_3 50 mgms.				5	2·0	7·0
16	$MgSO_4$ 20 mgms. KNO_3 50 mgms.				4	2·1	6·1
17	K_2HPO_4 20 mgms.				18	2·0	20·0

were, in this respect, inconclusive.) In the last recorded experiment (6-2-54), 200 c.c. of lake water were evaporated to dryness in one case and in another these residues were heated until the organic matter was charred. The residues were then each dissolved in 200 c.c. of distilled water. This treatment did not seem to impair the capacity of the medium for growing the test algæ. It seems therefore that the growth-promoting properties of the lake water are caused by relatively stable substances.

A few culture experiments were carried out with water samples from Lakes Albert, Rudolf, Bunyoni, George and Edward and from a dam (Jarvis Dam). The growth of cultures in these waters was as poor as it is in unfortified Lake Victoria water, except in the samples from Lake George and from below the thermocline in Lake Edward. These two samples supported a fair growth of both *Chlorella* and *Anabœna.* A discussion on the reasons for this falls outside the scope of this paper.

Conclusions

Attention has already been drawn by Beauchamp [12] to the fact that there appears to be a shortage of soluble sulphates throughout the African continent, and possible reasons were considered. The evidence was based mainly upon chemical analyses of water and soils. The experiments described above show that a shortage of sulphates is likely to be limiting the growth of phytoplankton in Lake Victoria.

Sulphur is an essential constituent of certain amino acids and the phytoplankton may be existing in a marginal concentration of dissolved sulphate. The suggestion has been put forward [12], therefore, that those fish feeding almost wholly on these plants might have a retarded growth rate. The problem may therefore have an economic aspect, for there is an acute shortage of protein in the diet of the local natives, and the most important fishery of Lake Victoria is based on *Tilapia* species which are plankton feeders [13].

Table V.—The Effect of Lake Water as compared to that of Distilled Water when both are used for making up Nutrient Culture Solutions. The Favourable Effect of Lake Water, unimpaired by moderate heating, is shown especially by the Cultures of *Anabœna*

Date of Experiment	Medium	Harvest in mgms./dry wt.	
		Anabœna	*Chlorella*
22–4–54 to 10–11–54	Enriched Lake Water	100·0	102·0
	Enriched Distilled Water	9·0	32·0
6–2–54 to 24–4–54 ..	Enriched Lake Water	84·3	14·4
	Enriched Distilled Water	37·7	27·4
17–9–53 to 23–12–53	Enriched Lake Water	70·0	45·0
	Enriched Distilled Water	7·0	30·0
8–1–53 to 12–3–53 ..	Enriched Lake Water	85·0	
	Enriched Distilled Water	34·0	
17–9–52 to 23–10–52	Enriched Lake Water	108·0	
	Enriched Distilled Water	1·0	
6–2–54 to 24–4–54 ..	Lake Water only	28·4	2·0
		23·7	
	Lake Water evaporated to dryness and re-suspended	21·0	1·6
	Lake Water evaporated to dryness, charred and resuspended	24·8	2·3

The sulphur cycle is undoubtedly of considerable importance in Lake Victoria. The importance of nitrogen and phosphorus cannot be dismissed, but whereas, during certain periods, phosphate and ammonia have been found in detectable quantities in the lake water, the content of sulphate has never reached this concentration. Fluctuations in sulphate concentration in the lake water are therefore not detectable.

In this lake, the inflows are very small compared to its volume, and the analytical evidence indicates that the supply of sulphate from these sources is likely to be of minor importance. The bottom deposits, after drying, yield comparatively high quantities of sulphate (e.g. 0.25 mgm. per gm. dry weight), but although these would appear to be the obvious main source of supply of sulphates, experiments have failed to show that any considerable quantity is released to the water under natural conditions [14]. The metabolic activity of certain molluscs has been shown to cause the release of certain quantities of sulphate into the surrounding water [15]. It is extremely difficult, however, to estimate how significant the activities of these molluscs are to the biology of the lake as a whole, but there would seem to be little doubt that they help to maintain existing levels of fertility.

The culture experiments described in this paper show that, as far as the test algæ are concerned, sulphates are a limiting factor for plankton growth as well as nitrates and phosphates. If these conclusions can be confirmed using local phytoplankton species as test algæ, then these salts must be regarded as playing a vital role controlling the biological productivity of Lake Victoria.

ACKNOWLEDGMENTS

I have to thank Dr. G. E. Fogg, University College, London, for a gift of the two original cultures of algæ used here and for much information concerning their mineral requirements.

I would also like to take this opportunity of thanking the Director, E.A. Fisheries Research Organization, for much encouragement and stimulating discussion during the course of these investigations.

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TABLE VI.—THE RESULTS OF PHOTOSYNTHESIS EXPERIMENTS CARRIED OUT ON THE 25TH AUGUST, 1953 NEAR THE CENTRE OF LAKE GEORGE, UGANDA. (TOTAL DEPTH OF STATION, 3 METRES, WATER TEMPERATURE 26°C.)

(*Suspensions of the different algæ were made and aliquot portions used in 250 ml. oxygen bottles. Exposure for the suspended and dark bottles was from 1100–1200 hours after which period, the dissolved oxygen concentration was estimated and shown as p.p.m.*)

Depth	0·5 metres	1·0 metres	2·0 metres	3·0 metres	Initial Samples	Dark Bottles
Using *Chlorella*	3·66	2·92	2·88	2·81	3·38	2·64
Using *Anabæna*	4·28	3·95	4·03	4·01	4·00	3·83
Using Phytoplankton ..	4·75	3·41	3·40	3·45	3·94	3·46

FEEDING VALUES OF LOCAL BARLEY, MAIZE AND OAT STRAWS

By A. Rogerson, Joint Animal Industry Division of E.A.A.F.R.O. and E.A.V.R.O.

(*Received for publication on 17th September, 1955*)

These experiments were carried out with Masai-type wethers, the technique and analytical procedures being identical with the methods detailed in earlier work published in this Journal (Rogerson, 1955).

The number of animals used, the diets fed and the duration of the trials were as follows:—

Straw	Sheep Used	Daily Diet	Effective Duration
Barley ..	5	600 g.	6 days
Maize ..	6	600 g.	6 days
Oat ..	6	600 g.	6 days

Results

Barley Straw

Records of the total food ingested, fæces voided and protein contained in the fæces are given in Table I.

From the data in Table I and from the comprehensive analysis of the barley straw and fæces, the nutritive value of the straw, shown in Table II, is calculated.

Table I

Sheep	Food Ingested (D.M. basis)	Dry Weight Fæces	Fæcal Crude Protein
	g	*g*	*g*
A	3168	1624	139·8
B	3168	1644	138·1
C	3168	1638	136·1
D	3168	1731	148·2
E	3168	1716	135·9

Table II.—Nutritive Value of Barley Straw

	Dry Matter Analysis	Digestibility (Mean of five sheep)
	per cent	*per cent*
Crude Protein	5·96	26·1
Ether Extractives	0·65	14·0
Crude Fibre	39·57	54·0
Nitrogen-free Extractives..	44·50	47·9
True Protein	3·82	10·1
Dry Matter	100·00	47·3
Organic Matter	90·68	49·5

Calculated Starch Equivalent .. 21·4
Calculated Protein Equivalent .. 1·0
Digestible Crude Protein .. 1·56%

Maize Straw

The principal trial data are given in Table III.

From the data in Table III and from the analysis of feed and fæces, the nutritive value of the maize straw, shown in Table IV, is calculated.

Table III

Sheep	Food Ingested (D.M. basis)	Dry Weight Fæces	Fæcal Crude Protein
	g	*g*	*g*
A	3193	1670	119·5
B	3193	1734	144·6
C	3193	1697	128·2
D	2708	1411	108·8
E	3193	1626	130·3
F	3193	1592	122·6

Table IV.—Nutritive Value of Maize Straw

	Dry Matter Analysis	Digestibility (Mean of six sheep)
	per cent	*per cent*
Crude Protein	4·33	6·8
Ether Extractives	1·68	100·0
Crude Fibre	36·51	57·7
Nitrogen-free Extractives..	50·91	47·5
True Protein	3·67	3·9
Dry Matter	100·00	47·9
Organic Matter	93·43	50·5

Calculated Starch Equivalent .. 27·6
Calculated Protein Equivalent .. 0·2
Digestible Crude Protein .. 0·27%

Oat Straw

Records of the total food ingested, fæces voided and protein contained in the fæces are given in Table V.

Table V

Sheep	Food Ingested (D.M. basis)	Dry Weight Fæces	Fæcal Crude Protein
	g	*g*	*g*
A	3175	1857	119·1
B	3175	1595	129·4
C	3175	1975	135·1
D	3175	1687	119·7
E	3175	1882	136·5
F	3175	1996	129·0

From the data in Table V and from the chemical analysis of the oat straw and the sheep fæces, the nutritive value of the straw, shown in Table VI is calculated.

TABLE VI.—NUTRITIVE VALUE OF OAT STRAW

	Dry Matter Analysis	Digestibility (Mean of six sheep)
	per cent	*per cent*
Crude Protein	5·29	23·8
Ether Extractives	1·38	54·1
Crude Fibre	37·95	43·5
Nitrogen-free Extractives..	45·18	41·9
True Protein	3·61	7·1
Dry Matter	100·00	40·7
Organic Matter	89·80	42·2

Calculated Starch Equivalent .. 16·0
Calculated Protein Equivalent .. 0·8
Digestible Crude Protein .. 1·26%

In Table VII are given the chemical analyses and estimated feeding values of British straws (Woodman, 1948).

TABLE VII

Figures on Dry Matter Basis

	Barley Straw	Maize (Stripped Stalks)	Oat Straw
Crude Protein ..	3·8	3·3	3·4
Ether Extractives	2·1	0·9	2·2
Crude Fibre ..	39·4	42·0	39·4
Nitrogen-free Extractives ..	49·3	51·6	49·3
Starch Equivalent	26·7	—	23·3
Digestible Crude Protein	0·9	—	1·2

The local straws have a higher crude protein content but this, apart from an enhanced digestible crude protein content in the barley straw, appears to be of little practical value, the maize protein being virtually indigestible and the oat protein less digestible than that found in a British straw. The lower starch equivalents of the local straws result from a decreased digestibility of the carbohydrate fractions, the digestibility coefficients of crude fibre and nitrogen-free extractives for the British oat straw being 54 per cent and 46 per cent respectively, compared with the 44 per cent and 42 per cent respectively in the local product. For barley straw the difference is confined to the non-fibrous carbohydrate fraction, the British figures being 54 per cent and 53 per cent compared with 54 per cent and 48 per cent respectively for crude fibre and non-fibrous carbohydrate in the local sample. It should be realized that this digestibility reduction has been noted in straws, the crude fibre contents of which are certainly no greater than those found in the British samples. The enhanced protein content of the local straws also suggests that they were no more mature and, in fact, probably less so than the samples with which they are compared.

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NUTRITIVE VALUES OF LOCALLY PREPARED POLLARDS AND DRIED BREWERS' GRAINS

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(*Received for publication on 17th September, 1955*)

The nutritive values of the pollards and brewers' grains were calculated from the results of digestibility trials conducted with six Merino-type wethers in digestibility crates. The daily diets fed and the periods of collection were as follows:—

Pollards.—500 g. Cynodon hay + 200 g. pollards (ten days).

Brewers' Grains.—600 g. Cynodon hay + 200 g. brewers' grains (five days).

The Cynodon hay was a bulk sample, carefully mixed after chaffing. Immediately previous to the trials now being recorded, the digestibility of this hay had been determined using the same six sheep in a trial lasting ten days. The calculated nutritive value of the Cynodon hay used as the basal ration is given in Table I.

TABLE I.—CYNODON HAY BASAL DIET

	Dry Matter Analysis	Digestibility (Mean of six sheep)
	per cent	*per cent*
Crude Protein	9·31	53·3
Ether Extractives	1·62	37·3
Crude Fibre	35·58	68·1
Nitrogen-free Extractives..	42·22	51·6
True Protein	8·33	50·9
Dry Matter	100·00	55·5
Organic Matter	88·73	58·3

Calculated Starch Equivalent .. 31·2
Calculated Protein Equivalent 4·6
Digestible Crude Protein .. 4·96%

RESULTS

Pollards

Records of the total food ingested, fæces voided and protein contained in the fæces are given in Table II.

TABLE II

Sheep	Food Ingested (D.M. basis) Hay	Food Ingested (D.M. basis) Pollards	Dry Weight Fæces	Fæcal Crude Protein (Wet analysis)
	g	*g*	*g*	*g*
A ..	4180	1694	2255	254·1
B ..	4180	1694	2440	258·4
C ..	4180	1694	2162	266·5
D ..	4180	1694	2286	265·7
E ..	4180	1694	2222	252·8
F ..	4180	1694	2314	272·6

Assuming the hay portion of the ration to be digested as when fed alone, then the nutritive value of the pollards can be assessed as in Table III.

TABLE III.—NUTRITIVE VALUE OF POLLARDS

	Dry Matter Analysis	Digestibility (Mean of six sheep)
	per cent	*per cent*
Crude Protein	19·43	73·7
Ether Extractives	3·33	55·9
Crude Fibre	6·75	23·3
Nitrogen-free Extractives..	66·44	82·7
True Protein	16·52	81·5
Dry Matter	100·00	75·2
Organic Matter	95·95	77·4

Calculated Starch Equivalent .. 63·6
Calculated Protein Equivalent .. 13·9
Digestible Crude Protein .. 14·32%

The local pollards are comparable in analysis and feeding value to the product sold on the British market as second-grade, coarse middlings or sharps (fine wheatfeed), the analysis and feeding value of which are given in Table IV.

TABLE IV

	Dry Matter Analysis	Digestibility
	per cent	*per cent*
Crude Protein	18·4	73·0
Ether Extractives	5·2	86·7
Crude Fibre	7·0	23·3
Nitrogen-free Extractives..	64·8	82·1

Calculated Starch Equivalent .. 65·5
Calculated Protein Equivalent .. 12·6
Digestible Crude Protein .. 13·46%

The digestibility coefficients of the crude protein, crude fibre and nitrogen-free extractives in this British sample are seen to agree very closely with the local by-product. The amount of digestible ether extractive material in the local sample is little more than 40 per cent of that expected in the British product.

Dried Brewers' Grains

The quantities of food ingested, fæces voided and the crude protein contained in fæces are given in Table V.

TABLE V

Sheep	Food Ingested (D.M. basis)		Dry Weight Fæces	Fæcal Crude Protein (Wet analysis)
	Hay	Dried Brewers' Grains		
	g	g	g	g
A ..	2484	908	1444	160·6
B ..	2484	908	1338	146·6
C ..	2484	908	1313	131·1
D ..	2484	908	1351	150·2
E ..	2484	908	1515	177·4
F ..	2484	908	1400	180·2

Assuming the hay portion of the ration to be digested as when fed alone, then the nutritive value of the brewers' grains is as shown in Table VI.

TABLE VI

	Dry Matter Analysis	Digestibility (Mean of six sheep)
	per cent	*per cent*
Crude Protein	21·37	72·6
Ether Extractives	3·77	85·7
Crude Fibre	16·52	70·3
Nitrogen-free Extractives..	51·10	67·5
True Protein	20·88	83·6
Dry Matter	100·00	68·2
Organic Matter	92·76	72·3

Calculated Starch Equivalent .. 56·7
Calculated Protein Equivalent .. 15·3
Digestible Crude Protein .. 15·51%

Apart from a considerably lower fat content, the local product is very similar to its British counterpart, viz.:—

	Analysis	Digestibility
	per cent	*per cent*
Crude Protein	20·4	71·0
Ether Extractives	7·2	87·5
Crude Fibre	16·9	48·0
Nitrogen-free Extractives..	51·2	60·1

Starch Equivalent .. .. 56·7
Protein Equivalent .. .. 14·0
Digestible Crude Protein .. 14·5%

The main difference between the digestibilities of the local and British samples concerns the carbohydrate and fibre fractions, both of which show higher values in the East African sample. Although the matter was not specifically investigated, it is possible that this difference arises as an antifact due to an increase in the digestibility of these particular fractions in the basal ration consequent on the feeding of a higher level of crude protein.

NUTRITIVE VALUE OF PINEAPPLE RESIDUES (DRIED)

By A. Rogerson, Joint Animal Industry Division of E.A.A.F.R.O. and E.A.V.R.O.

(*Received for publication on 17th September, 1955*)

Four Masai-type sheep were used for the digestibility trial from which the feeding value of the pineapple residues was calculated. The basal diet, a meadow hay, was a bulk sample, carefully mixed after chaffing. Previous to the trial recorded here, the digestibility of this hay had been determined using six Masai sheep, including the four used here, in a trial lasting ten days. The feeding value of the meadow hay used as the basal ration is given in Table I.

Each of the four sheep received a daily diet consisting of 500 g. of the above meadow hay plus 200 g. of dried unmilled pineapple residues. The effective length of the trial was five days.

TABLE I.—MEADOW HAY BASAL DIET

	Dry Matter Analysis	Digestibility (Mean of six sheep)
	per cent	*per cent*
Crude Protein	8·50	51·0
Ether Extractives	1·17	11·1
Crude Fibre	37·35	69·0
Nitrogen-free Extractives ..	42·98	48·7
True Protein	7·86	53·9
Dry Matter	100·00	53·7
Organic Matter	90·00	56·8

Calculated Starch Equivalent .. 29·4
Calculated Protein Equivalent .. 4·3
Digestible Crude Protein .. 4·34%

RESULTS

Records of the total food ingested, fæces voided and protein contained in the fæces, are given in Table II.

Assuming the meadow hay portion of the ration to be digested as when fed alone, then the nutritive value of the pineapple residue can be assessed as in Table III.

TABLE II

Sheep	Food Ingested (D.M. basis)		Dry Weight Fæces	Fæcal Crude Protein
	Hay	Pineapple Residues		
	g	g	g	g
A ..	2070	828	1239	142·3
B ..	2070	828	1211	149·3
C ..	2070	828	1222	140·5
D ..	2070	828	1208	137·9

TABLE III.—NUTRITIVE VALUE OF PINEAPPLE RESIDUES

	Dry Matter Analysis	Digestibility (Mean of four sheep)
	per cent	*per cent*
Crude Protein	3·53	negative
Ether Extractives	0·50	negative
Crude Fibre	16·22	76·7
Nitrogen-free Extractives ..	74·50	79·2
True Protein	2·45	negative
Dry Matter	100·00	68·4
Organic Matter	94·75	71·8

Calculated Starch Equivalent .. 47·9
Calculated Protein Equivalent .. Nil
Digestible Crude Protein .. Nil

The unmilled pineapple residues, although coarse in texture, were very readily eaten by the sheep. The Starch Equivalent value is moderate; it compares roughly with a very good meadow hay, undecorticated cotton or groundnut cake and broad bran. Due possibly to the physical nature of the pineapple residues, the apparent digestibility of the protein is negative. That is to say, that not only is the thirty grams of protein contained in a sheep's daily feed of pineapple residues completely unavailable, but another thirty grams of the protein contained in the basal ration of hay is also lost to the sheep. It is possible that milling of the residues would reduce the fæcal protein output and it is hoped to repeat the determination using such a product.

RELEASE OF NEW CEREAL VARIETIES—1955

By H. C. Thorpe and G. E. Dixon, Department of Agriculture, Kenya

(*Received for publication on 23rd September, 1955*)

The undermentioned cereals have been released by the Department for sowing during the 1955/56 season. In conformity with accepted procedure the varieties have been tested in trial plots on the Plant Breeding Station, Njoro (7,100 ft.), and subsequently with farmers in various parts of the territory. Fuller details of the procedure were given in an earlier article.

Wheat No. 354.P.3.B.2.B

A selection from the cross Warigo x Stirling, made at the Plant Breeding Station, Njoro, in 1944.

354 is a beardless, white-chaffed, white-grained variety of mid-season maturity, fair straw strength, and good baking quality. Seedling tests show it to be susceptible to K9 and K11 forms of black stem rust, but it has not been attacked in the field. The variety possesses resistance to brown leaf rust, and to yellow ear rust up to approximately 7,000 ft. in Kenya.

354 has done quite well on a field scale at Endebess, Moiben, Nakuru, Rongai and Njoro; and it should be suitable for areas between 6,000 ft. and 7,000 ft. in Kenya. It matures in 5–5½ months, depending on altitude and climatic conditions. In view of possible yellow ear rust damage growing much above 7,000 ft. is not advised.

This variety likes fertile conditions for best results.

Wheat No. 356.A.12.C.

A selection from the cross 184.P.2.A.1.E x 192.Q.2.A.(L), made at the Plant Breeding Station in 1944.

This selection is a bearded, white-chaffed, white-grained variety of earlyish maturity, fair straw strength, and fair baking quality. It is resistant to K9–K13 forms of black stem rust, but shows susceptibility to the form K14, and was slightly attacked (but not damaged) at Njoro in 1954.* The variety possesses resistance to brown leaf rust, and to yellow ear rust up to approximately 7,000 ft. in Kenya.

The variety has done well on a field scale at Nakuru and Njoro; and it should be suitable for areas between 6,000 ft. and 7,000 ft. in Kenya. It matures in 4½–5 months, depending on altitude and climatic conditions. In view of possible ear rust damage, growing much over 7,000 ft. is not advised.

Wheat No. 261.E

A further selection from the cross 261. This is a bearded, white-chaffed, white-grained variety of early maturity and good baking quality, taking about two weeks longer than 261.R. The straw is somewhat stronger than that of 261.R.

261.E has done well in the Nakuru and Solai Valley areas, and should be suited to all areas in Kenya from 6,000 ft. to 7,000 ft. with a growing season of some five months.

Vikota Oat

A direct importation from the United States of America, received at Njoro in 1948.

Vikota is a short-strawed, white-husked variety of earlyish maturity. It has shown satisfactory field resistance to disease, particularly stem and leaf rusts. It has done well on a field scale at Kitale and Eldoret, and in the higher country in smaller scale tests. It should be suitable for areas between 6,000 ft. and 8,500 ft. in Kenya. It is possible Vikota may be suitable for altitudes above this figure; and this is still the subject of test. It takes roughly five months at 6,000 ft. and rather more in the higher areas.

Vikota is a grain oat rather than a silage or hay type. It is unfortunately unacceptable for porridge-making on account of a peculiar taste in the grain.

REFERENCE

Thorpe, H. C. (1949). "A note on the Release of some New Cereal Varieties", *E.A. agric. J.*, XIV, pp. 210-211.

* Since this time a crop at Naro Moru has been severely attacked by stem rust of unknown form.

TRIALS OF FUNGICIDES FOR THE CONTROL OF DAMPING-OFF IN PINE SEEDLINGS

II—Field Trials

By I. A. S. Gibson, Forest Department, Kenya

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Three sets of field trials have now been completed for a small range of fungicides, selected on the basis of results from recent glasshouse trials which were reported in a previous paper.[1] These have been carried out over a range of forest stations, selected as far as possible to cover conditions typical of those found in the Kenya Forest Department, and based on the following lines.

Trial Series No. 1

Experiments in this series were designed to compare the effect of Dithane Z-78 and Perenox on seedling populations of *Pinus patula* Schl. and Cham. Seed beds were divided into equal strips (6 ft. × 3 ft.) and sown uniformly, and the fungicides were applied as 0.3 per cent suspensions at a rate of one gallon per two square yards at the time of sowing and at weekly intervals until emergence was complete. Two seed-bed strips were selected at random for each treatment. Within each strip two counting areas (6 in. × 6 in.) were selected on a random basis and marked at sowing time; healthy and diseased seedlings were recorded within these areas when emergence was complete and the experiment brought to a close. A summary of these results with those from the other two series is given in Table I. Period of experiments, July to September, 1954.

Trial Series No. 2

This was carried out along similar lines to Series No. 1, but was designed to test Dithane Z-78 as a treatment either applied once at

Table I.—Summary of Results of Field Trials

Forest Station (Name and Height above sea level)	Dithane Z-78			Perenox		Thiram 63%	Phelam	Leytosol B	Crag 658	
	Trial Series Number									
	1	2	3	1	3	3	3	3	1	3
Marashioni, 8,800 ft. ..		—P								
Kaptagat, 8,000 ft. ..	—	—	—	+	0	P	0	0		P
Bahati, 7,900 ft. ..	+	—	+	++	+	+	+	0		++
Elburgon, 7,800 ft. ..			0		0	0	0	0		
Kiandongoro, 7,800 ft. ..	+		0							
Sorghet, 7,500 ft. ..	+		0							
Mt. Elgon, 7,300 ft. ..									++	
Muguga, 6,800 ft. ..	+		0		0	0	0	0	P	
Machakos, 6,200 ft. ..		+*								
Meru, 4,700 ft.		+								
Kwale, 1,200 ft.			++		+	P	+	+		P

Note—

0 denotes no marked effects of treatment.

— denotes a decrease in emergent population of treated plots compared with nil plots.

P denotes marked phytotoxic effects on seedlings after emergence.

\+ and ++ denote respectively fair and good degree of disease control.

* denotes verbal report only.

sowing time as a 1.2 per cent suspension or as a 0.3 per cent suspension applied weekly; each treatment was added to the bed at one gallon per two square yards. Results for the single treatment have not been included in Table I, as effects followed those for weekly treatments but were less pronounced. Period of experiments November, 1954, to March, 1955 (Meru experiment, November, 1955).

Trial Series No. 3

Experiments in this series were carried out along lines similar to those of previous glass-house trials.[1] Randomized block designs were employed covering eight treatments replicated six times. Plots were based on small seed boxes (6 in. × 6 in.) or plant trays subdivided by shingles (7 in. × 8 in.), local soil being used incorporated where possible with soil from beds in which damping-off had recently occurred. No inoculum or soil other than that originating from the forest station of the trial was used. A counted number of *P. patula* seeds was sown in each plot and fungicides were applied as 0.3 per cent suspensions at a rate of one gallon per two square yards weekly until emergence was complete. Seedling populations and numbers of diseased plants were counted for each plot. With the exception of Elburgon, results given in Table I summarize those for two experiments at each station. Period of experiments, May, 1955, to September, 1955.

Discussion

While the number of experiments has not been as great as was originally hoped, the results are sufficient to indicate that none of the treatments have shown the standard of uniform disease control which would be required for general nursery practice in Kenya. Effective control of seed bed loss by Dithane Z-78 seems to diminish with increasing altitude: other preparations have shown erratic results and many have proved phytotoxic in certain areas. Variations in temperature, humidity, and soil conditions that exist between forest stations, as well as variable incidence of *Rhizoctonia solani*, *Pythium ultimum* and an occasional weakly pathogenic *Fusarium* sp. as pathogens, may account for this lack of uniformity.

Further materials are being put on trial for the control of damping off in pine seed beds in the future, but present results suggest that it is unlikely that any one fungicide will prove effective and safe throughout the forest nurseries of Kenya.

I would like to thank all foresters concerned in carrying out these trials for their interest and willing help.

References

[1] Gibson, I. A. S. (1955). Trials of fungicides for the control of damping off in pine seedlings. *E. Afr. agric. J., 21*, p. 96.

BRIEF NOTES OF THE PROCESSING OF SOME SHARK PRODUCTS AT THE KENYA COAST

By T. E. Allfree, Kenya Game Department, Fish Division

(*Received for publication on 15th October, 1955*)

It may come as a surprise that sharks are especially fished for and are a valuable product at the Kenya Coast. For instance, the small Bajune Islands produce 450 tons of shark meat a year. Shark flesh is sold fresh, wet salted, or dry; but there are also by-products of the shark which are not generally known, and they form the subject of this brief article.

Fins

Those sharks which have bones rather than rays have fins of no commercial value, i.e. all fins from the Nurse shark (*Orectolobidæ*); the side fins of the sawfishes (*Pristidæ*); and the top lobes of all tail fins. Again, it is not worth processing for sale the fins from sharks whose overall length is less than five feet.

Saleable fins should be removed by cutting in a curve in order to remove as little bone or meat with the fin as possible. They should be soaked for a few hours in clear sea water to facilitate the removal of any bone and flesh from the base of the fins. They should then be dried until absolutely hard and stiff, and during this process they should be protected from rain. They should be kept clear of sand. When packed in sacks in a godown a little D.D.T. should be packed in with them to keep out beetles.

In East Africa fins are usually graded and sold in the following grades: White fin (large); White fin (small); Black fin (large); Black fin (small) and Tail fins. The White fins include those which are a light grey in colour, and those of a light yellow colour from the large rays (*Rhinobatus* sp.). The prices paid to the fishermen vary, of course, but the following figures are a guide:—

White fins (large): Sh. 140 to Sh. 120 per frasila (36 lb).

White fins (small): Sh. 80 per frasila.

Black fins (large): Sh. 100 per frasila.

Black fins (small): Sh. 70 per frasila.

Tail fins: Sh. 30 per frasila.

These fins find their way to China, where they are considered a great delicacy.

Liver Oil

It has been proved that the vitamin content of shark liver oil caught off the East African coastline is too low to be of economic value, and the oil has no export value; but it is used locally for the following purposes:—

Wood Preservative.—The liver oil is generally used on native craft as a preservative, but the demand is limited as the oil from the sardine (*Simu*) is much preferred.

Soap Manufacture.—For this purpose the oil has to be clean, clear and with only a faint odour. To prepare the oil the liver is cut up into small pieces, placed with a little water in the inner receptacle of a double boiler, and heated for about 40 minutes. On standing, the oil will rise to the surface, where it can be skimmed off. A better but more expensive method, only warranted by having large quantities of liver, is to chop or grind the liver, and place in a steam-jacketed kettle with water, in the ratio of two parts of water to one part liver. The contents are heated to 180° F. and live steam is blown through the mass at a pressure of 15 lb. till the oil is freed. This takes about 20 minutes. After cooling, the oil is separated by a centrifuge; then it goes through filter cloths to strain out all solid matter. The price of the oil varies greatly, but during recent years it has been purchased by the soap manufacturers at from Sh. 6 to Sh. 8 per gallon.

Shark Flesh for Sale as Fresh Meat

Shark meat should not be left in metal containers owing to a chemical reaction. The dark meat from a large shark is not suitable for sale as fresh meat, as it has a strong "sharky" smell, and tends to become rancid more quickly than the other meat. Shark meat fillets should be washed in clean sea water or clean brine (4 lb. of salt per gallon of clean fresh water). If the fillets can then be iced down for 24 hours, but not below freezing point, this will remove the "sharky" smell and taste. Thereafter the fillets should be soaked in clean brine and well stirred for two hours before sale. If ice is not available, most of the characteristic smell and taste can be removed by soaking with constant stirring in brine for six hours.

Dry Salting.—The Kenya market will not accept heavily salted dry shark flesh, which, however, finds a market in Zanzibar and Tanganyika. For the Kenya market, shark flesh should be dry salted and left in piles for 12 hours, thereafter washed and, for preference, shade dried in a strong draught. Good, sterilized, pure salt is not available locally. Of the local salt which is available, it is of advantage to use matured dried salt which has been stored for at least a year. The quality of the salt can also be improved by a few hours' drying. It should always be a fine medium grade.

TEETH AND JAWS

Good sized, sound teeth and jaws, nicely cleaned, find a sale in the tourist trade. The backbone can easily be made into a novelty walking-stick, and teeth are made into brooches and other items for the tourist trade. These teeth should be removed by boiling the jaw for a short time in water to which a small amount of caustic soda has been added.

SHARK SKIN AND FERTILIZERS

Sharks are not caught off the Kenya coast in sufficient quantity to warrant any reference to either of these two uses, and besides, they each require a lot of capital.

REVIEW

INDUSTRIAL FIBRES, 1955. A summary of figures of production, trade and consumption relating to cotton, wool, silk, jute, flax, sisal and other hemps, mohair, coir kapok, rayon and other man-made fibres. 185 pages, price Sh. 5 net (5s. 4d. post free). Obtainable from H.M. Stationery Office or from the Secretary, Commonwealth Economic Committee, 2, Queen Anne's Gate Buildings, Dartmouth Street, London, S.W. 1.

World production of the chief industrial fibres in the 1953-54 season was about 4 per cent below the record achieved a year earlier, while preliminary figures for the 1954-55 season show a further reduction of around 3 per cent, according to the 1955 edition of *Industrial Fibres* published by the Commonwealth Economic Committee. The reduction in 1953-54 was entirely accounted for by the decline in jute output, while in the following season it was due mainly to the fall in cotton. The Commonwealth's share in world fibre production has continued to rise, particularly marked advances being recorded in cotton and hard hemp (sisal). Aggregate consumption of apparel fibres again increased during 1954, but this did not prevent a further rise taking place in stocks of cotton and to a lesser extent, of wool, since production of these materials was still in excess of consumption. Prices of the different fibres showed somewhat divergent movements during the first part of 1954, but in the second half of the year the general trend was downwards. World trade in industrial fibres was slightly larger in 1954 than in the previous year, sharp falls in wool and jute being more than outweighed by the improvements recorded in cotton and rayon.

The fall in fibre output during the 1954-55 season was largely in the apparel varieties, since production of non-apparel fibres showed very little change compared with the previous season. Nevertheless, the Commonwealth share in both types was higher, notably in cotton, sisal, and the newer protein and synthetic fibres group.

The report summarizes developments in cotton production for the season 1954-55 and notes that the crop is expected to be some seven per cent smaller than last season, owing chiefly to the reduction in United States' output following the imposition of acreage restrictions. Wool production during the same season showed a slight increase, while rayon output in 1954 reached a new peak. Among the non-apparel fibres jute and sisal showed higher production totals in 1954-55 than in the previous season.

World price movements of the main natural fibres during 1954 were less uniform than in recent years, though on balance there was a tendency for them to fall slightly, in contrast to the moderate rise which had occurred in 1953. Prices of cotton and wool rose during the early months of the year, but fell steadily in the latter half, the decline being especially marked in the case of wool. Silk and hemp prices also declined during 1954, while those of jute which fell heavily in the early part of the year rose considerably in the latter months, as a consequence of the severe flood damage in Bengal.

IHEME STOCK FARM, IRINGA, SOUTHERN HIGHLANDS PROVINCE, TANGANYIKA

Summary and abstracts from Mr. W. P. Bewg's report on "An Account of the Development of the Grazing and Grassland at Iheme"; prepared by H. J. van Rensburg, Pasture Research Officer, Mpwapwa

The farm, which was maintained as a stock farm from 1948 to 1954, is situated 24 miles south of Iringa where the Dabaga road branches off the Great North road, and it lies approximately 6,000 ft. above sea level. The vegetation consists of highland *miombo* woodland with grass varying in height and density according to tree cover and soil fertility in different locations. The soil is derived from old granite and is poor. The total area of the farm was 2,464 acres, some sixty of which were cultivated when the farm was taken over by the Veterinary Department in December, 1948.

Grazing Conditions and Grazing Improvement

During the rains there is plenty of grazing but once the dry season begins the grass dries up very quickly. In early years there was a tendency for cattle to graze in the vicinity of the buildings, resulting in overgrazed and denuded areas while more distant grazings were unused and became rank. Controlled grazing and fire control measures had to be organized. This was complicated on account of the introduction of exotic stock and in running a considerable number of herds, factors which made controlled grazing difficult. Road traces and fire breaks, however, served as useful boundaries to subdivide areas for grazing control and greatly facilitated supervision. It was found most satisfactory to graze a comparatively small area closely and then to move on to the next field, giving the former an opportunity to recover. This method does not only bring on further satisfactory growth but also seems to improve the quality of the grazing as well as the basal cover and it prevents undesirable selective grazing.

Selective clearing by mattocking small shrubs and weeds while leaving large trees brought about a remarkable improvement in grazing on about 300 acres of land. This clearing was accomplished with about three men days per acre in the first year, and two men days per acre in the second year to clean up the regrowth. After that the goats seemed to cope with any further regrowth by browsing. The combination of clearing and mowing at the right time with fire exclusion did not only alter the appearance but increased the grass yield from virtually nothing to one ton per acre. Fire, properly controlled and judiciously used, was also found to have a beneficial effect. Burning at the end of the dry season removed unwanted fibrous and dry grass and produced good growth with the first rains while also checking regenerating bush growth. It was found desirable to graze closely during the early part of the rains and then to protect areas for hay-making towards the middle or the end of the rainy season. This method prevented coarse fibrous growth, while hay could be made when the rains were over and yields of about 30 cwt. hay per acre were obtained. The carrying capacity improved from about 20 acres per beast in 1950/51 to 10 acres per beast in 1954; but in spite of improved grazing management, it was still necessary to use supplementary feeding in the dry season.

Observations on Pasture and Fodder Grasses

Rhodes Grass (*Chloris gayana*).—In general, the first year after sowing seed, Rhodes grass did not give good results and one tended to think in terms of semi-failure. Once established, however, with correct treatment it takes heavy punishment and proved to be by far the most valuable grass on the farm for grazing.

Over 25 acres were established from seed, either alone or undersown with oats and in both cases did very well. A good crop of hay exceeding one ton per acre was obtained, followed by green aftermath for grazing.

The established pastures were always grazed by European stock and only after these animals were transferred to Mpwapwa was the full value of Rhodes grass pastures appreciated. No sooner were the Zebu stock put on these pastures when the milk yields rose most noticeably and appreciably.

Star Grass (Cynodon dactylon).—Star grass, similarly to Rhodes grass and *Setaria sphacelata* only grows satisfactorily on cultivated and manured fields and does not thrive on infertile hard soil.

Elephant Grass (Pennisetum purpureum).—In damp valley soil, on ridges with manuring, elephant grass yielded about 50 tons of valuable green fodder per acre and dry season yields were quite large. On a comparative basis it outyielded Kale six times and turnips eleven times. Elephant grass seems to be the most suitable green fodder that can be grown and it deserves considerable emphasis for future use.

Setaria sphacelata.—It seems that with adequate seed supplies a great deal could be done with this grass and that it would be most useful for pasture and fodder. Sown together with Rhodes grass it produced a good pasture while it also mixed well with star grass. *Setaria sphacelata* in both cases provided green growth until late in the season. On parts of the field where silt had accumulated it established itself from seed. It is capable of producing grazing at the end of the dry season when normally the stock tend to drop in condition.

By judicious grazing, five acres of Setaria carried six beasts for the latter two months of the dry season. With inter-row cultivation and dung the same five acres kept six yearling bulls throughout practically the whole of the next dry season. After folding, the field was closed for hay, yielding one ton hay per acre; and during the following dry season it provided grazing for ten cattle for two months.

Setaria splendida.—This grass reacted very similarly and in some cases seemed to do even better than *Setaria sphacelata.*

It would seem that in spite of soil poverty and poor natural herbage, fodder supplies and grazing can be considerably improved by establishment of suitable fodder and pasture grasses as well as by grazing management and improving the natural grassland.

BACK NUMBERS

The Editor wishes to purchase the following back numbers of this Journal, or to exchange them for current numbers:—

Vol. I: Nos. 1, 2, 3, 4, 5 and 6.

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Vol. VIII: Nos. 1, 2, 3 and 4.

Vol. IX: Nos. 1, 2, 3 and 4.

Vol. X: Nos. 1, 2, 3 and 4.

Vol. XI: Nos. 1 and 2.

THE IMPORTANCE OF WATER IN THE MANAGEMENT OF CATTLE

By M. H. French, Joint Animal Industry Division of E.A.V.R.O. and E.A.A.F.R.O.

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Owing to the constant concern with the metabolic needs of animals for protein, energy, minerals and vitamins, and the attempt to keep up to date with the voluminous and growing literature dealing with these problems, there is an excuse for many workers, in the well-watered temperate areas of the world, omitting to emphasize the fundamental importance of water in animal nutrition. On movement from these areas to the semi-arid regions, where long droughts alternate with seasonal and often short rainy periods, and where livestock experience serious difficulties in finding and consuming sufficient herbage to maintain growth, reproduction and normal sustenance, the seasonal water shortages exert such dominating influences that attention is quickly and importantly focused on livestock requirements.

The presence of adequate water in body tissues is an essential prerequisite for the normal maintenance of life, and water is a fundamental constituent of all living cells. It is so intimately concerned with the transformation of nutrient and excretory matter between the digestive system, the cells of the different body tissues and the excretory organs, that its presence is taken for granted until one is confronted with the consequences of its shortage. Whereas starving animals may lose nearly all their glycogen and fatty reserves, half their body protein and about 40 per cent of their body weight and still live, the loss of only 10 per cent of body water causes serious disorders and further losses may quickly lead to death. Temporary water shortages are consequently of greater immediate significance than corresponding deficiencies of solid foods.

With cattle, the developing fœtus, up to about four months of age, contains over 90 per cent of water, but its water content falls to about 76 per cent of its total weight by the time the calves are born. It falls slowly during life and may reach 60 per cent in ordinarily conditioned steers and an even lower percentage (down to 48 per cent) in very fat oxen. While the proportions of water in the empty liveweights (i.e. excluding stomach contents) of other farm animals and birds vary, they exhibit a similar reduction as maturity and fattening weights are approached. Although the water content of the blood remains uniform, the amount of water in the different organs and body tissues varies considerably with nutritional plane and the stage of fatness. Kidney fat, which represents an extreme case of fat accumulation, may contain only 4.4 per cent of water with 93.9 per cent of fat in fattened animals, but may be changed to 81.4 per cent of water and 9.6 per cent of fat in animals maintained for a long period on sub-maintenance rations. Other tissues, such as the psoas muscle, exhibit a very constant water content (78 per cent) on a fat-free basis.

Animals vary in their water requirements and some wild African species, such as the gerenuk and dikdik, can survive under dry season conditions, miles from water, on dew and the limited moisture intake from dried-up plants. Other game, such as the bushbuck, reedbuck, impala, oryx, kongoni, kudu, hartebeeste, eland, wildebeeste and zebra, are dependent to varying degrees on water and are not found more than a day's journey away from permanent supplies, while buffalo, bush-pig, waterbuck, puku and sitatunga are even more dependent on, and are closely associated with, permanent waters. Among domesticated animals, the camel is less dependent on water than most species, while certain sheep can survive on irregular and small intakes. High-producing European cattle breeds rapidly become unproductive if water supplies are limited, although indigenous Zebu cattle can subsist for months in the dry season when watered only every third day. Buffaloes, pigs and fowls must have water daily and horses cannot exist for long without it.

There is a direct relationship between water requirements and the environment to which animals can adapt themselves, and the differences in the requirements of European and Zebu cattle are partly responsible for the limited success of the former in the semi-arid areas to which the latter are accustomed. Admittedly the failure to maintain normal body temperatures seriously affects the adaptability of European cattle to such conditions,

but ability to walk long distances in search of the sparse food and to exist for relatively long periods without water are important characters differentiating between European and Zebu types in semi-arid areas. Bonsma gives an example (Table I) of differences between European and indigenous cattle in South Africa.

Lack of adequate watering facilities causes the less adaptable cattle to hang around the permanent watering-places, to eat out the grazing in these regions, and then to suffer from malnutrition and the probable intestinal parasitic infestations which are likely to develop in these areas.

The performance of work causes the formation of heat in the body and the elimination of the extra heat load is partly achieved by the excretion of water vapour in the accelerated breathing. The water requirements of work horses and trek oxen vary with the amount of work they perform. In the case of lactating animals, the amount of water consumed is similarly increased in proportion to the quantity of milk secreted but, in both cases, the volume of water drunk as such is considerably influenced by the water contained in the normal foods. Consequently, on lush grass, silage or other foods containing a high water content, the liquid consumption is correspondingly much less than when the animals exist on dried-up herbage, hay or other foods containing little water. The total water intake of an animal therefore includes the quantity drunk as such, the amount taken in as part of the foodstuffs consumed and, in addition, the water produced during the metabolism of proteins, carbohydrates and fats from absorbed dietary supplies or withdrawn from the body tissues.

Water of metabolism arises from intracellular oxidative reactions and Rowntree quotes the weights of water produced by the body oxidation of fat as 101.7, of starch as 55.5, and of protein as 41.3 units respectively per 100 weight units of the food components metabolized. Metabolic water is also formed during the dehydrations involved in the normal synthesis of proteins, fats and carbohydrates and, from the continuity of such oxidative and reductive processes, is constantly available and can contribute importantly to body needs. The dependence of hibernating animals on the metabolic water, yielded from the catabolism of fats and carbohydrates during their seasonal sleeps, is an extreme example of the reliance which can be placed on such supplies by certain animal species but, in the case of all types of domestic stock, this source of water is comparatively small and insufficient to meet the requirements of normal activity. It is unquestionably insufficient to meet the needs of high-producing stock, especially those secreting large volumes of milk or laying a large number of eggs.

Apart from specific production needs, water is constantly needed to balance the continuous losses from the kidneys, the intestinal tract, the skin and the lungs. In urine, water is the vehicle for the excretion of a number of catabolic products, particularly minerals and urea, and the richer the diet in minerals and proteins the larger are the quantities excreted and the greater the volume of water required for their solution and transport. There are marked differences in water requirements for urinary excretion between species, depending partly on the nature of the nitrogenous end-products of protein catabolism. Urea is the principal excretory product of protein metabolism in mammals. It is toxic in concentrated solution in the body fluids and an adequate excretory rate is essential for continued health, but this excretion depends on the availability of adequate water supplies. The main excretory

TABLE I

	After 24 hours Without Water		After 48 hours Without Water		
	Loss in weight	Reduction in food consumption	Loss in weight	Reduction in food consumption	Recovery in weight after two weeks
	per cent	*per cent*	*per cent*	*per cent*	*per cent*
Afrikander ..	1·5	0·0	9·0	56·0	96·0
Exotic Beef Breed	15·0	24·0	21·0	62·0	92·0

nitrogenous compound in birds is uric acid, and not urea, but the subsequent dehydration of the urinary excretion in the cloaca reduces the volume of water lost to the body. The breakdown of proteins to uric acid also provides more metabolic water to the organism than does an equivalent catabolism to urea and, in consequence, birds have relatively lower water requirements than larger animals and are less sensitive to temporary shortages.

A century has passed since it was first demonstrated that large quantities of water and body salts are secreted into the stomach and intestines from the tissues and are subsequently reabsorbed. These secretions into the alimentary canal have the same osmotic pressures as normal body fluids and any food solutes, in the lumen of the canal, are normally made isotonic with the blood serum by admixture with the water and salts secreted into the gut and the simultaneous absorption of isotonic fluids therefrom. Hypertonic solutions, after ingestion, are diluted with saline gut secretions until the osmotic pressure of the resulting fluid in the lumen approximates to that of the body serum. Similarly ingested hypotonic solutions lose water by absorption but will gain salts from the alimentary secretions whilst doing so, until an osmotic balance is obtained with the body fluids. While dilution of ingested hypertonic fluids occurs in the stomach, subsequent absorption is negligible until the ingesta reaches the intestines. Both excretion and absorption take place simultaneously in the small intestine, but absorption is the predominant feature from the large intestine and is intimately involved in the elaboration of fæcal residues possessing normal solidity.

It is obvious that the alimentary canal exerts little protective action on the internal environment because osmotically balanced solutions of salts continue to be absorbed even when the body tissues contain a surfeit. Similarly, secretions of body fluids into the alimentary canal occur even when the volume and saline concentration of the body fluids are depleted although, under normal circumstances, this latter activity causes no serious repercussions because these fluids and their saline contents are subsequently reabsorbed and circulated in the body. When the gastro-intestinal contents are constantly vomited or excreted by diarrhoea, the uncontrolled secretory activities can lead to serious body salt depletion or to excessive dehydration.

Whereas in mammals water losses can be divided into those caused by evaporation and those due to liquid excretions, the former occur from the skin and respiratory surfaces and the latter through the urine and sweat excretions. The insensible loss of water from the skin apparently does not involve the transfer of water through the skin to evaporate on its surface, but represents the escape of water vapour originating from the sub-corneal layers. The epidermal layer, even after separation from the underlying tissues, retards evaporative rates because it is permeable to gases and not liquids, while the removal of this layer over blisters permits a marked increase in evaporative rates which then approximate to those from exposed interior tissues. So long as the sweat glands are inactive, the insensible perspiration from the skin and the evaporative losses from the respiratory system both depend on the temperature and water vapour pressure differences between the body surfaces and the atmosphere. Evaporation from the respiratory tract is proportional to the ventilation rate but the expired breath is usually not quite saturated with water vapour. The warmth of the inspired air modifies the temperature in the outer respiratory passages but, with rise of air temperature, the vapour tension of the alveolar air rises and larger amounts of heat are then dissipated during normal breathing. Consequently, the amounts of water and heat dissipated are considerably increased if the rate of breathing also increases.

In man and certain animals sweating occurs when body heat production or environmental temperatures and humidities are sufficiently high that body heat cannot be eliminated at the necessary rate to ensure thermal regulation. Sweating rate is, however, not controlled by water intake and like insensible perspiration is regulated by the blood flow to the skin. Since skin temperature may be reduced by the evaporation of sweat, it is probable that sweating is induced by a rise of the internal body temperature. The composition of sweat varies between individuals and with salt intake but, unlike the insensible perspiration, it contains sodium and chlorine. The presence of these ions indicate its formation from the extra-cellular body fluids, although sweat is hypotonic and contains different proportions of these ions from the ratios found in the extra-cellular fluids. Certain individuals always secrete a sweat containing more sodium and chlorine than others and there is evidence that, in man, prolonged residence in hot climates

leads to the secretion of a less concentrated sweat. Perspiration, both sensible and insensible, is designed for the regulation of temperature and is less attuned to the adequacy or otherwise of body water supplies. Insensible perspiration decreases slightly in severe dehydration when the extra-cellular fluids contain large quantities of salts. Sweating also is less copious when men are deprived of water and their body temperatures are then less easily controlled.

Certain animals, such as bovines, perspire either extremely little or not at all under normal conditions of health, and the burden of maintaining body temperatures around normal levels in hot environments devolves more on the elimination of the surplus body heat in the water vapourized during breathing. Respiration rates are considerably increased in bovines in hot environments, so that pure-bred and high-grade European cows under hot, humid coastal conditions pant and salivate in an extra endeavour to reduce their body heat burden. Under such unfavourable environmental conditions the drinking of frequent and large amounts of water helps in the maintenance of normal body temperatures, because of the heat used in warming the water intake to normal body temperatures and the subsequent elimination of this heat load during urination.

The intake of water and dissolved salts from the alimentary canal are regulated by the central nervous system and any large fluid losses, such as by sweating, vomiting, diarrhoea or hæmorrhage, cause thirst often of an intense kind. While the absorption rate is little affected by the degree of dehydration in the tissues, body constancy in the volume and composition of its fluids is largely controlled by variations in the kidney excretions. The elimination of abnormal or superfluous constituents and the conservation of the proper proportions of water and other essential body components are achieved by kidney filtration, secretion and readsorption.

In the lower forms of life, the osmotic pressure of the urine never exceeds that of the blood, but in mammalia the terminal kidney tubules and the loop of Henle can reabsorb water and consequently are able to produce urine with a higher osmotic pressure than that of plasma. Glomerular fluid, in its passage through the proximal kidney tubules, loses its reducing substances and large amounts of water and saline components to leave a liquid in the excretory tubules with the same osmotic pressure as, but of a different composition from, that of body fluids. In the loop of Henle and the distal convoluted kidney tubules, electrolytes and water are further absorbed to leave a urine of greater osmotic concentration than that of the tissue fluids. Urea and salt do not compete for water but urea is concentrated to the greater extent. On the other hand the concentrations in the urinary fluid of chlorides, bicarbonates, sodium, potassium, inorganic phosphates, glucose and creatinine appear limited by their aggregate osmolar concentrations and they compete with one another for water. The water excretion in urine thus depends on the quantity as well as on the nature of the solutes requiring elimination. Urea is always more concentrated in urine than in plasma but the kidney capacity for handling urea is limited and high protein diets, which favour an increase in urea production, consequently augment the volume of the urinary liquid. Body dehydration means that less liquid can be spared for urea excretion and consequently non-protein nitrogen retention increases during water shortages. Urine volume also decreases during body dehydration until only sufficient is voided to remove less than the maximum quantity of solutes awaiting excretion.

Apart from its important function in excreting waste products of metabolism, urination also serves as a buffer against sudden alterations in the quantities of water eliminated by other methods of disposal. Sudden temperature drops for instance can cause a marked reduction in the quantity of water eliminated from the body surface and the pulmonary system so that surplus fluid in the body must then be adjusted by increased urinary output. This variation adjustment occurs daily in the semi-arid areas of East Africa where there is a marked (30° F.) reduction in atmospheric temperatures between day and night. Alternately, there is an equally frequent and marked but opposite change during the mornings as the sun heats the atmosphere and indirectly causes a rapid rise in the evaporative output of body heat. The volume of urine has then to be correspondingly reduced unless proportional increases occur in liquid consumption. During long-continued drought periods when animals are forced to do without water for up to three-day intervals, the output of urine decreases considerably and the fæces become drier, harder and more obviously coated with mucus. This latter factor is quite different to

what happens when animals are laboratory fed and allowed to drink *ad lib.* Under the latter conditions the water content of ox fæces can sometimes remain remarkably constant, around 82 per cent, in spite of changes in the proportions and water contents of the dietary constituents. The water content of sheep fæces, on the other hand, does not exhibit such constancy with variations in the diet, even when the animals have water permanently in front of them.

Under desiccating conditions and shortages of water, although the fæces may become drier and harder, the digestive processes are conducted at normal, or near normal, degrees of moisture content because of the secretion of fluids into the stomach and small intestine. It is the lack of water in the body tissues which leads to the more severe dehydration of fæcal residues in lower regions of the alimentary tract. This steady dehydration when cattle are allowed water only every third day, in spite of the dry herbage and long walks involved, does not lead to unruly behaviour when the animals approach water-holes. In fact, it is a common dry season sight in Masailand to observe thousands of cattle waiting patiently in their herds, for long periods and in sight of water, for their turn to drink. On reaching the water, they drink steadily for several minutes during which they swell visibly and then stand for 10–15 minutes before taking a further short drink prior to the usual ten-mile return journey to their night quarters. Subsistence on the low food and water intakes, together with the long daily walks (up to 20 miles per day) in search of food or water, impose a severe strain on the animals and liveweight losses under such conditions can be considerable and rapid. Such severe deprivation of water is usually not for long, although drinking on alternate days is a system which can be continued for weeks without apparently harmful effects on the animals.

It would be imagined that, with the onset of the rainy season, animals which had been living under such hard conditions would quickly respond to nutritious green herbage. This, of course, is the normal reaction of healthy cattle, but in some years and in certain overstocked regions this response can be seriously delayed. In bad years, or where there is gross overstocking, many animals die of thirst or starvation towards the end of the dry season and the survivors can be losing weight at a serious rate when the first rains occur. Green grass shoots rapidly develop but it sometimes happens that liveweight losses become accelerated, and that stock which have just survived the dry season shortages lose weight even more rapidly, become weaker, and a certain percentage die in spite of the green herbage. The effects of wetting the herbage and changing from hay to green grass was studied by French with normally fed and not starved cattle at the end of the dry season, and Table II summarizes the results.

The loss of weight in native Zebu stock at the beginning of the rainy season was attributed to (*a*) loss of appetite for rain-soaked mature coarse herbage; (*b*) diarrhoea and reduction of stomach contents; (*c*) disinclination to eat the dried herbage once the oxen have tasted the young grass growth; and (*d*) cold, damp periods increasing the maintenance energy needs.

After the incidence of disease, water shortage during the long dry seasons is probably the next most important factor affecting the distribution of stock populations in semi-arid areas. Cattle must live within a reasonable distance of permanent water, either natural

TABLE II

Period	No. of days	Diet	Average dry matter consumption/day	Average daily liveweight increase
			kg.	*lb.*
1	20	Dry hay	5·20	+0·85
2	7	Wet hay (to simulate the effects of rain)	4·92	−0·95
3	11	Dry hay } mixture	2·83	−0·18
		Green grass }	1·82	
4	10	Green grass	5·58	−0·30
5	14	Natural grazing	N.D.	+0·36

supplies or man-made storage reservoirs, although, as stated by Hornby in Tanganyika, "the native husbandryman is only capable of maintaining large flocks and herds on land, the vegetation of which is indicative of arid or sub-arid conditions". In the vicinity of the watering places the annually recurring spectacle of grazed-out pastures causes liveweight losses and serious retardation in growth rates and productive capacity, and forces the animals to wander farther and to spend longer periods searching for food. Conditions may so deteriorate that, as indicated above, stock-owners strike a balance between the time wasted, from a grazing point of view, in trekking to water, and the imperative need to allow their animals a minimum quantity to drink. A typical situation in Masailand exists with the main kraals situated some 10 miles from permanent water. On the first day the animals walk in to water and back home but can collect little food on the way. On the second day they graze out away from the water and return home ready for watering on the third day. As available food supplies are consumed, they may stay out in temporary pens further away from their permanent homes and return to the latter only on the third day ready to proceed to water on the fourth. Considering the dried nature of the grazings, their limited amounts and the distances travelled, it is obvious that Zebu cattle have considerable ability to exist on very restricted water intakes.

To determine whether such watering restrictions influenced digestibility, three pairs of Zebu oxen were acclimatized to a ration of hay and to a system which provided water, either *ad lib.*, or once only on every second or on every third day. The results (Table III) indicated that, in stall-fed oxen, digestibility coefficients for dry matter, organic matter, ether extract and nitrogen-free extractives, were not affected by the freqency of watering. On the other hand, as the period between watering became extended, the digestibility of the crude fibre fraction was significantly increased. There was a general decrease in the digestibility of crude protein fraction when water intake was restricted to once in every 72 hours but the decrease did not attain a statistical significance.

With the restriction of water intake a significant decrease took place in the daily dry matter consumptions (Table IV) so that, in spite of the better digestion of crude fibre, the actual starch equivalent intake became significantly lower (at the 5 per cent level) when watering only every third day. The quantity of digestible crude protein available to the animals also decreased significantly with the less frequent intake of water.

TABLE III

	Average Digestibility Coefficients (Per cent)				
	Organic Matter	Crude Protein	Ether Extract	Crude Fibre	N-free Extract
Water *ad lib* daily	48·4	58·4	13·2	49·5	45·4
Watered for 1 hour every second day	49·1	58·4	11·5	53·0	45·2
Watered for 1 hour every third day	49·4	57·7	12·8	53·5	45·8

TABLE IV

	Daily Dry Matter Consumption	Digestible Crude Protein	Starch Equivalent Value
	kg.	*per cent*	
Water *ad lib* daily	4·4	5·1	33·0
Watered for 1 hour every second day	4·1	5·1	33·6
Watered for 1 hour every third day	4·1	5·0	33·9

Shortage of water in many areas in the dry season is paralleled by an inability to find and consume a sufficient quantity of dry herbage. Although oxen, on such restricted food intakes but able to drink when they liked, appeared able to digest crude fibre more efficiently than when consuming the same hay at a higher rate, no differences were significant in the calculated nutritive values of these hays according to the level of consumption. The net result is that under the dry season combination of fodder shortage and inadequacy of drinking-water, livestock reach a subsistence level of nutrition and the normal digestive and metabolic processes are unable to protect significantly against the consequences of the two subnormal intakes.

Apart from these digestive observations, the animals on the three-day watering régime were less thrifty, more listless and dejected than the animals drinking more frequently. Their skins were drier and old skin scars became more obvious. The animals produced much drier fæces, the excretion of which was facilitated by an obvious mucous coating.

A twelve-day balance experiment on another series of housed oxen when watering *ad lib.*, and once only on every second or every third day, indicated (Table V) that the animals on the more infrequent watering system were in a lower potassium balance than when water was more readily available. Possibly they suffered from a withdrawal of cellular fluids and their solutes, consequent on the need for mobilizing tissue fluids to counteract the inadequacy of water intake. The less frequent watering reduced nitrogen retention in parallel with increasing liveweight losses and also led to negative retentions of magnesia.

The above observations on restricted food and water intakes were conducted under indoor stall-feeding conditions. It is almost certain that more severe effects would have been produced if the animals had had to walk long distances in search of both food and water. The animals which were watered every third day would then have deteriorated more rapidly in general appearance and liveweight.

Under these experimental conditions it was observed that water consumptions of the Zebu oxen, over the 31 weeks of experimentation, varied according to the figures in Table VI, from which it can be seen that the oxen, allowed to drink during one hour every second

TABLE V.—AVERAGE DAILY NITROGEN AND MINERAL BALANCES

	Nitrogen (gm. N)	Calcium (gm. CaO)	Magnesium (gm. MgO)	Potassium (gm. K_2O)	Sodium (gm. Na_2O)	Chlorine (gm. Cl)	Phosphorus (gm. P_2O_5)
Watered *ad lib*	+10·2	+8·4	+0·6	+10·5	+0·3	+0·8	+0·9
Watered once every 2nd day	+2·5	+8·6	−0·2	+10·8	±0·0	+0·9	+0·3
Watered once every 3rd day	+7·2	+7·0	−0·1	+5·8	+0·1	+0·6	+0·8

TABLE VI.—SIX-DAY WATER CONSUMPTIONS UNDER STALL-FED CONDITIONS

No. of 6-day Periods	WATER *ad lib*	WATERED FOR 1 HR. EVERY 2ND DAY		WATERED FOR 1 HR. EVERY 3RD DAY	
	6-day actual consumptions (gal.)	6-day actual consumptions (gal.)	Percentage of *ad lib* consumption	6-day actual consumptions (gal.)	Percentage of *ad lib* consumption
First 6 periods	16·5	15·8	95·7	12·2	73·6
First 12 periods	17·0	15·7	92·6	12·2	71·8
Second 12 periods	16·8	14·9	85·1	11·4	67·8
Third 12 periods	17·2	15·9	86·8	11·0	63·9
Total 36 periods	17·0	15·1	89·2	11·5	68·3

day, consumed only 89.2 per cent of the amount drunk by the animals which had water constantly in front of them. The animals which were allowed to drink only during one hour every third day consumed 31.7 per cent less than those which could drink whenever they wished. The figures in the Table demonstrate that the consumptions of animals on the restricted intakes became progressively lower as the period of restriction became extended. The results in Table VI refer to the quantities of water drunk by mature Zebu oxen, varying from 530–620 lb. at the commencement of the study and between 485–560 lb. at the end, under entirely stall-fed conditions. They cannot be interpreted as applicable to the practical management conditions under semi-arid systems of husbandry.

These results were obtained when the second twelve-week period coincided with the cool season of the year, the first period being obtained under moist atmospheric conditions and falling temperatures, while the third period coincided with drier air conditions and slightly rising temperatures. To bring these results more into line with practical conditions, a further trial was conducted on mature oxen to ascertain how water consumptions, under such advantageous conditions above, compare with the amounts drunk when the animals are exposed to slightly more rigorous conditions. The results (Table VII) are shown for an average of 13 animals in each group.

From these figures it can be deduced that when watering once every second day, exposure in an open yard from 9 a.m. until 2 p.m. increases the consumption by mature Zebu oxen by 6.5 per cent above the intakes of cattle housed continuously. When they are exposed for the same period in a nearby paddock, the increase in water consumption over continuously housed animals amounts to 19.3 per cent. Reduction in consumption due to the change from drinking once every second day to once in three days amounted to 16.6 per cent for the permanently housed cattle compared with the estimate of 23.9 per cent in the previous trial. In this second case, the period of estimation is five weeks instead of 31 weeks in the former study. It is a further rather striking point about the above water consumptions that the levels are low compared with the normally quoted daily requirements

Table VII.—Variations in Water Consumptions of Zebu Oxen under Different Management Conditions (6-day Averages)

Period		Water Consumption	Frequency of Watering	Management Conditions
		gal.		
Group I	1–5–39 to 30–5–39 ..	14·8	For 1 hour every second day	Loose inside a covered yard
Group II		14·9		
Group I	31–5–39 to 29–6–39 ..	14·7	For 1 hour every second day	Loose inside a covered yard
Group II		15·7		Loose in an open yard from 9 a.m. to 2 p.m., and then inside with Group I.
Group I	30–6–39 to 4–8–39 ..	12·3	For 1 hour every third day	Loose inside a covered yard
Group II		14·7		Loose in a nearby paddock from 9 a.m. to 2 p.m., and then inside with Group I.

of European breeds, and the data in Table VIII are given in further illustration of this fundamental difference between indigenous and grade-European steers in a sub-tropical semi-arid environment. The steers of both types were running together, but in this case the Zebu oxen had been well-fed and cared for and were consequently heavier than the normal animals in their natural surroundings. Such differences can be ascribed to breed differences and not to husbandry practices as the animals had been reared under comparable conditions.

These figures indicate that at 1½ years of age the ½-Ayrshire × Zebu steers drank approximately 68.4 per cent more water than comparably well-managed Zebu oxen and that at 3½ years old the difference in intake was 39.2 per cent. These figures were obtained when the animals spent 5 hours (9 a.m. till 2 p.m.) daily in a paddock close to the covered open yards where they spent the remainder of their time. Each period lasted 30 days and it is possible that the differences in consumption would have been more pronounced had the water in the daily waterings been constantly available throughout the day, instead of being offered on a restricted basis. This latter procedure is, however, more in line with the management practices existing at that time on many ranching estates. The reduced consumptions which resulted from watering once in 24 hours to once in 48 hours was roughly the same with the two breeds and at the two ages recorded. The percentage reductions through watering only every second day were 15.5 per cent and 12.7 per cent for the indigenous and grade stock at 1½ years old and was 10.9 for both types at 3½ years of age, values closely in line with the figures recorded above for mature Zebu oxen living a sheltered existence.

As very few local cattle can live under such easy conditions, it was decided to determine the consumptions of Zebu cattle which had to walk 4½ miles to water. The quantities drunk in four 30-day periods are shown in Table IX.

The first point which clearly emerged from these figures was the much higher consumptions when animals were grazing and walking to water than were recorded for the oxen living the sheltered experimental conditions reported upon earlier. The experimental periods do not correspond in season with the earlier studies, but the figures in the above table show an average increased water intake of 53.8 per cent above the levels consumed by housed oxen that had water constantly in front of them. For the period when watered every second day the outside animals drank 72.9

TABLE VIII.—WATER CONSUMPTIONS OF WELL-FED ZEBU AND GRADE EUROPEAN OXEN

Watered for 1 hour	Average 6-day Water Consumptions			
	1½-year old Steers		3½-year old Steers	
	Zebu	½-grade Ayrshires	Zebu	½-grade Ayrshires
	gal.	gal.	gal.	gal.
Once daily	10·3	24·2	25·5	35·7
Every second day ..	8·9	21·4	22·3	31·1
Once daily	10·9	24·9	24·6	34·0

TABLE IX.—WATER CONSUMPTIONS OF NORMAL MATURE ZEBU OXEN

Period	Watering Regime	Period	Average 6-day Consumptions
			gal.
I	Once daily	31–5–38 to 30–6–38	26·7
II	Once every other day	12–7–38 to 11–8–38	23·2
III	Once daily	17–8–38 to 16–9–38	25·5
IV	Once every other day	22–9–38 to 16–10–38	29·1

per cent more than those which were housed. By calculating the consumptions during periods II and III against the averages of periods I and III and periods II and IV, respectively, it is estimated that the reductions in water consumption when watering every second day, compared with once-daily drinkings, were 13.1 per cent and 12.5 per cent, figures which compare favourably with the reduced intakes recorded for continuously housed oxen (10.8 per cent) and for partially housed Zebu cattle (10.9 per cent) not subjected to long walks in the heat of the day.

From the above series of results, it is clear that water consumption varies appreciably with frequency of drinking, the environmental conditions including air temperature and humidity, and with the amount of walking in search of both food and water. Also the water intake varies considerably between indigenous Zebu and grade animals containing exotic temperate blood. For entirely stall-fed animals, the ratio of water/food consumptions were 3.4/1, 2.6/1 and 2.2/1 for animals respectively on *ad lib.* water, and when watered only once either every second or every third day. For well-fed Zebu and grade bulls between 1 and 4 years, with moderate exercise, the ratios cannot be accurately quoted but are roughly 3.3/1 and 4.1/1, respectively. The latter are somewhat higher than those extracted from the literature and quoted by Leitch and Thomson, but are presumably higher because of the higher environmental temperatures and/or the drier atmospheric conditions.

References are often encountered to the ability of camels to endure long journeys with little or no water and to the relation between this character and the production of water from its hump. By analogy the humped Zebu has been credited with similar powers but, unfortunately, the potentialities of this mechanism have been exaggerated. From figures obtained in Tanganyika, hump weights average from 3.8 lb. in two-tooth stock to 6.1 lb. in mature males, although individual humps can reach twice these weights. Even if all the hump tissue were composed of fat, calculation quickly indicates that the total weight of metabolic water which could be produced therefrom could not suffice for a single day's water requirements for an adult ox. The available figures indicate that the quantity of hump fat available for such metabolic purposes is no greater than the caul and kidney fats.

Over wide areas of East Africa, particularly in the dry season when many local water supplies have dried up, the only water available becomes increasingly concentrated and contains a number of salts. The latter are generally chlorides, carbonates, bicarbonates or sulphates of sodium, calcium and magnesium, with small quantities of other metals and acids, and such high salt concentrations are sometimes reached that animals refuse to drink. The tolerance of different kinds of stock to waters of differing saline contents and concentrations has been investigated in many countries. Animals forced to drink strong solutions without any preliminary acclimatization may be injured. Normally, stock do not choose such dangerously concentrated supplies and will naturally drink normal waters if the latter are available. In practice, if animals become accustomed to a salty water supply they can tolerate much higher salt concentrations than if forced to drink the more concentrated solutions without a preliminary conditioning period. It appears that 1.5 per cent total salts is the upper limit which can be employed with safety for sheep and cattle but that lower concentrations should be given to pigs and milking cows. Sodium chloride appears less injurious than calcium or magnesium chlorides, while alkaline solutions are more dangerous than straight saline mixtures. French has shown that the consumption of alkaline waters, containing 370 parts per 100,000 of sodium carbonate, and therefore similar to supplies from East African volcanic regions, increases the retention of sodium and chlorine in oxen but reduces the calcium, potassium, magnesium and phosphate balances. He associates this body depletion of calcium and phosphate in stock, forced to drink such waters, with the commonly occuring erosion of the permanent teeth in sheep and oxen living in areas dependent on alkaline waters for a large part of the year. In such regions, not only are the molars badly and irregularly worn away, but individual or all incisors may be worn down to gum level. It is not difficult to visualize what a serious handicap this wearing away of the teeth may be when the stock are dependent on hard, fibrous herbage. Also, in these areas, bone fractures are frequent, indicating their reduced strength and ossification consequent upon the removal of minerals by the ingested alkaline waters.

With the direction of attention to problems involving a knowledge of the state of water in living structures, it is becoming obvious that

all water in living tissues does not necessarily exist as free water but that a certain small proportion may become intimately bound with organic structures and therefore a part of the disperse phase. The amount of water so bound is, however, sufficiently small that this fraction can be neglected in practical animal production studies.

From the above discussion it is obvious that water is the most abundant constituent of most body tissues, but it is no longer possible, particularly in semi-arid regions, to regard it merely as the solute vehicle for body chemical compounds and their reaction products. It plays a most intimate role in nutrient solution and absorption and a vital part in the alimentary removal of noxious metabolic products, in the maintenance of body temperature and in the retention of normal osmotic pressures and turgidity in tissue cells. The water content of body vital organs tends to be fairly constant although the percentage in various tissues and its rates of turnover vary with age and pathological conditions. Despite these long-term variations and in spite of the continuous excretion and the discontinuous intake of water, the osmotic pressure relationships of the body fluids are maintained at remarkably uniform levels. In addition to its important ionizing and transport properties, water has a high specific heat and therefore plays a significant role in absorbing the heat liberated during metabolic reactions, while the latent heat utilized in its vaporization contributes importantly to the regulation of body temperatures. It also performs a number of specific functions, such as serving as a cushion for the protection of the spinal cord from mechanical injuries, as a medium for transporting the blood corpuscles and the gases utilized in or produced by oxidation, as a bone-joint lubricant, and as a transmission medium in sight and hearing. The degree of an animal's independence of its environmental conditions is regulated by its ability to maintain its internal organs and their metabolisms constant in spite of fluctuating external conditions and, for this fundamental hæmostatic purpose water is an essential and dominating unit.

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WORLD PLOUGHING CONTEST OF 1956

The World Ploughing Contest of 1956 and the international agricultural machinery demonstration—the first such demonstration in Britain for many years—will be held at Shillingford, near Oxford, England, on 10th, 11th and 12th October, this year.

This is announced by the British Ploughing Association and the World Ploughing Organization, who add that teams from different countries will be competing for the title of World Ploughing Champion and the Golden Plough trophy—emblematic of world supremacy in the art of ploughing.

It is further announced that the 1956 British National Championship Ploughing Match will be held at the same time.

The combination of the World Ploughing Contest—the fourth in the series—and the international agricultural machinery demonstration will assure the event of world-wide attention on the part of all who are interested in agricultural machinery and the vital problem of food production.

Approximately 450 acres have been reserved on the site at Shillingford for the field demonstration of agricultural machinery. Here the finest equipment not only from British manufacturers, but also from other countries, will be demonstrated under actual working conditions, enabling the visitor to compare the efficiency and performance of various makes.

The Formation of the British Ploughing Association and the World Ploughing Organization

The Workington and District Agricultural Society, which was formed in 1945, played an important part in promoting a world ploughing championship. Each year a champion team of Canadian ploughmen came over to England to compete in the Workington Society's "Empire" ploughing match, and as an almost inevitable result of such close liaison and friendly rivalry, there grew up the idea of world championship.

In 1951 the British Ploughing Association was formed and, with the inception of the World Ploughing Organization in 1952, British and overseas delegates attended an international conference, promoted by the British Ploughing Association, at Stirling in Scotland. The conference was called to organize the World Ploughing Organization on a permanent basis, draw up international rules agreeable to all and decide where the first world match should be held in 1953. The Canadian delegate extended an invitation on behalf of Canada and, in particular, the Ontario Ploughmen's Association, which would be celebrating its 40th anniversary. This invitation was accepted and the match was held at Cobourg, Ontario, in October, 1953, with 20 contestants from 11 countries. The following countries have been, or will be, hosts to the world match since then: 1954, Eire; 1955, Sweden, 1956, England; 1957, U.S.A.; 1958, Germany.

The world match represents in agriculture what the Olympic games mean to sport. This international gathering of craftsmen has already promoted firm friendships among rivals from competing countries.

SOWING DENSITY AND DAMPING-OFF IN PINE SEEDLINGS

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It is generally accepted in forest nursery practice that the risk of damping-off loss in the seed-bed increases in direct proportion to sowing density [1, 2]. This has been demonstrated in the experiments of Hartley [6], but no investigations into the cause of this relationship have been traced.

There are three ways in which increased sowing density might be expected to favour the spread of damping-off pathogens in the seed-bed:—

(*a*) By giving rise to a dense mass of emerged seedlings which would restrict evaporation from the soil and give damp conditions favouring the spread of most damping-off pathogens.

(*b*) By increasing the number of seedlings in the seed-bed which, as a source of nutrient, are available exclusively to the pathogen.

(*c*) By reducing the average distance between individual seedlings, facilitating spread of pathogens from plant to plant, and thereby reducing the competition from soil saprophytes for nutrient in the intervening soil spaces.

The experiments described below have been concerned with damping-off in pine seedlings caused by *Rhizoctonia solani* Kühn. Their object has been to determine whether, in any of these three ways, increases in sowing density bring about increases in damping-off.

Materials and Methods

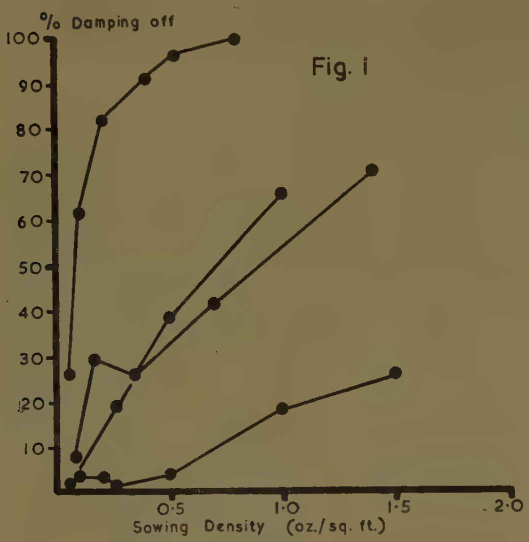
Experiments were all carried out in the glasshouse at temperatures between 95° F. and 55° F. and relative humidities between 35 per cent and 85 per cent. With the exception of two experiments in which seeds of *Pinus radiata* D. Don. were used, all experiments were made with seeds of *Pinus patula* Schl. & Cham.; these had a germination of 70 per cent to 80 per cent. Seeds were sown in small seed boxes, 7 in. by 8 in. and 4 in. deep, in local forest soil and covered with a uniform quantity (usually 50 gm.) of soil known to contain *R. solani* and a smaller proportion of *Pythium ultimum* Trow. In later experiments a mixture of an 8–10 day-old sand* culture of *R. solani* was sometimes used, mixed with soil. Randomized block designs were employed involving three to five sowing densities replicated six or more times; supplementary treatments were sometimes applied between blocks. Plots were watered sufficiently to keep the soil thoroughly wet but not waterlogged. Disease incidence was recorded a week to ten days after emergence of seedlings; the numbers of healthy and diseased emergent seedlings were counted and, in conjunction with the number of seeds originally sown, percentage values for pre-emergence and post-emergence loss were calculated. In the following tables disease incidence has been stated as post-emergence disease only, as in all experiments the pre- and post-emergence phases of damping-off were closely correlated.

At the end of each experiment in which soil containing pathogens was used as inoculum, diseased plants were sampled from a range of plots, incubated on 2 per cent. malt agar at 26° C. for 24 to 36 hours, and examined for pathogens. It was found that plants attacked by *R. solani* and *P. ultimum* could be readily distinguished in this way. Both pathogens have been tested against seedlings of *P. patula* and *P. radiata* from the stage of germination until one week after emergence and have been found to be pathogenic over all this period. This confirms results obtained by Gravatt [5] and Fisher [3].

Results

The results of four experiments to determine the relationship between damping-off and sowing density are shown in Fig 1. The incidence of disease has varied considerably between experiments, but in each the statistical regression obtained between sowing density and damping-off has been highly significant. Pre-emergence and post-emergence (damping-off) loss in each experiment has also been found to be closely correlated (Table I). In all these experiments naturally infected soil was used for inoculum, containing mostly *R. solani* with some *P. ultimum*.

* The medium for these cultures consisted of a mixture of 100 gm. sand, 3 gm. corn meal, and 15 ml. water.



Soil Moisture

Two experiments have been completed to determine how far variations in soil moisture following increases in sowing density can account for increases in damping-off such as observed above. In both, series of three or four levels of sowing density, replicated six times, were set up. Half the replicate plots were covered with bell jars lined with damp blotting paper, ensuring a saturated atmosphere within, and the other half were left exposed under normal glasshouse conditions. Soil containing a high proportion of *R. solani* to *P. ultimum*

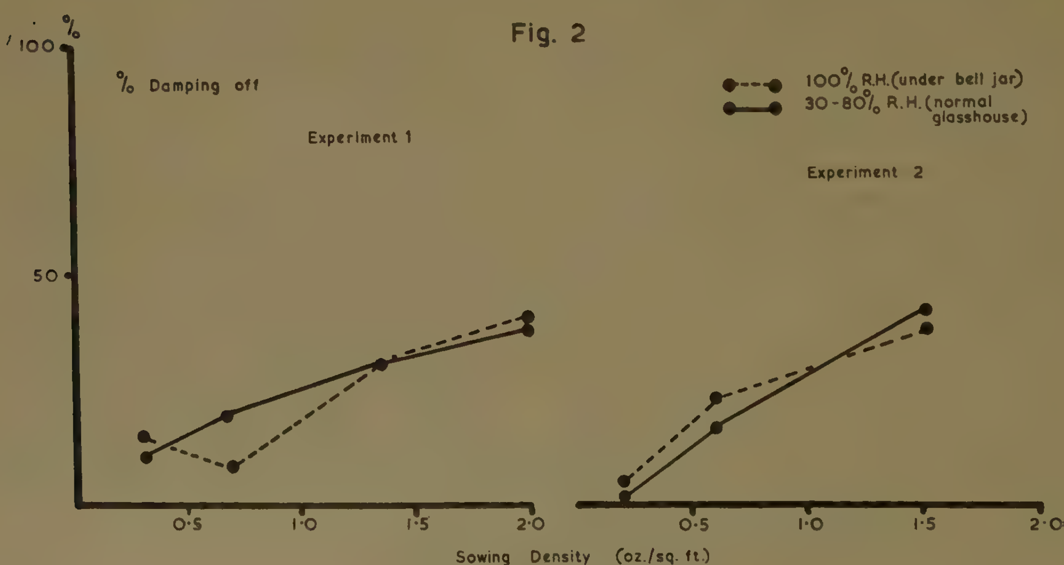
TABLE I.—EFFECTS OF VARIOUS SOWING DENSITIES ON PRE-EMERGENCE AND POST-EMERGENCE LOSS

Sowing Density (oz. per sq. ft.)	Damping-off Loss (per cent)			
	Experiment 1		Experiment 2	
	Pre-emergence	Post-emergence	Pre-emergence	Post-emergence
2·10	76·5	66·9	—	—
1·50	—	—	52·8	21·2
1·00	68·9	42·2	41·9	17·8
0·50	41·1	24·3	31·8	4·9
0·25	35·7	24·8	19·7	3·5
0·13	30·7	7·1	—	—

NOTE.—Values for pre-emergence loss include a constant of about 20 per cent due to non-viable seeds in the batch sown.

was used as inoculum. The results of these experiments (Fig. 2) show little difference between the incidence of disease under the two conditions. If increased damping-off at high sowing densities had been the result of restricted evaporation and damp soil conditions, then an equally high disease incidence would have been expected at the lower sowing densities under a saturated atmosphere. As this is not so, it is concluded that variations in soil moisture between high and low sowing densities play little part in causing the corresponding variation of disease incidence.

Further support to this conclusion is found in Table I, where pre-emergence and post-emergence losses are shown to be equally affected by variation in sowing density. As a



high sowing density can only be expected to modify soil moisture and thus spread of disease in the post-emergence phase, the variation of some other factor with that of sowing density must be postulated to account for the variations of post- and pre-emergence disease observed.

Soil Nutrient

The importance of this factor in determining the relationship between sowing density and damping-off has been investigated in two experiments, in which the following treatments were compared:—

(1) A series of sowing densities without extra treatment.

(2) A similar series to which supplementary quantities of dead seeds were added to each plot to bring the total number of seeds per plot to that of the maximum planted. Supplementary seeds were killed by autoclaving at 15 lb. pressure for five minutes.

A top dressing of soil containing *R. solani* was added uniformly to all plots. Each series was set up in triplicate.

The results of these experiments (Table II) show a consistently higher disease incidence in plots receiving extra dead seeds than in corresponding plots without them. This would be expected if the activity of the pathogen varied with the amount of nutrient available to it. *R. solani* has been described by Garrett [4] as a soil-inhabiting fungus which would be able to colonize the dead seeds added in this experiment and to spread more rapidly as a result. The results shown in Table II show that, within plots sown with mixtures of dead and viable seeds, an increase in incidence of damping-off follows an increase in the proportion of living seeds sown. This may be because live seedlings are more suitable than dead seeds as food bases for the spread of *R. solani*, or due to saprophytic competition to *R. solani* for nutrient in the dead seeds.

The relative effects of nutrient supplied as live and dead seeds on the activity of the pathogen has been investigated in a third experiment in which the following treatments were compared:—

(1) A series of sowing densities without extra treatment.

(2) A similar series to which dead seeds had been added as in the previous experiments.

(3) A series to which supplementary sowings of live seeds, sufficient to bring the total planted per plot to the maximum planted, was added one week after the first sowing. In this way the first sowing emerged and was ready for disease recording before the second sowing had appeared.

TABLE II.—THE EFFECT OF THE ADDITION OF SUPPLEMENTARY DEAD SEEDS TO THE RELATIONSHIP BETWEEN DAMPING-OFF AND SOWING DENSITY

Sowing Density (per sq. ft.)				Damping-off per cent	
Live Seeds		Dead Seeds		Experiment 1	Experiment 2
Oz.	No.	Oz.	No.		
0·18	645	—	—	0·3	1·7
0·36	1290	—	—	5·4	3·9
0·72	2580	—	—	18·6	13·1
0·18	645	0·54	1935	7·1	7·8
0·36	1290	0·36	1290	10·1	8·1
0·54	1935	0·18	645	11·9	—

Each treatment was set up in triplicate. A heavy top dressing of soil known to contain *R. solani* was added to all after the second sowing of live seeds in treatment 3.

The results of this experiment (Table III) were somewhat irregular, but the average disease incidence showed a significant increase from plots without supplementary seeds, through those with extra dead seeds, to those with extra live seeds. This indicates that the living seedling provides a better food base than a dead seed for the spread of *R. solani* in the soil.

TABLE III.—THE EFFECT OF THE ADDITION OF SUPPLEMENTARY LIVING AND DEAD SEEDS ON THE GRADIENT OF DAMPING-OFF WITH SOWING DENSITY

Sowing Density (per sq. ft.)		Damping-off per cent		
Oz.	No.	No extra seeds	Dead seeds added to 0·72 oz. per sq. ft.	Live seeds added to 0·72 oz. per sq. ft.
0·18	645	10·1	18·4	31·9
0·36	1290	16·5	36·6	69·9
0·54	1930	27·2	59·7	46·3
0·72	2580	35·5	—	—
Mean	—	22·3	38·2	49·4

A small laboratory experiment has been carried out to compare the growth rate of *R. solani* in soil and with nutrient derived from germinated seedlings. Sclerotia of *R. solani* were planted singly in tubed 1 per cent soil agar slants; sets of five of these slants were made up with various numbers of germinated pine seeds per tube, killed in the course of sterilization. After intervals of two and four days after inoculation the linear mycelial growth of these cultures was measured. The results (Table IV) show that a significantly greater growth rate after four days, as well as a thicker mycelial mat, was obtained in cultures containing seedlings.

These results not only show that spread of *R. solani* in the soil is closely related to available nutrient, but also that increases in damping-off following increased sowing density are due to corresponding increases in the nutrient available to the pathogen in the soil.

TABLE IV.—THE EFFECT OF THE ADDITION OF GERMINATED SEEDS OF *P. patula* TO SOIL AGAR ON THE GROWTH OF *R. solani*

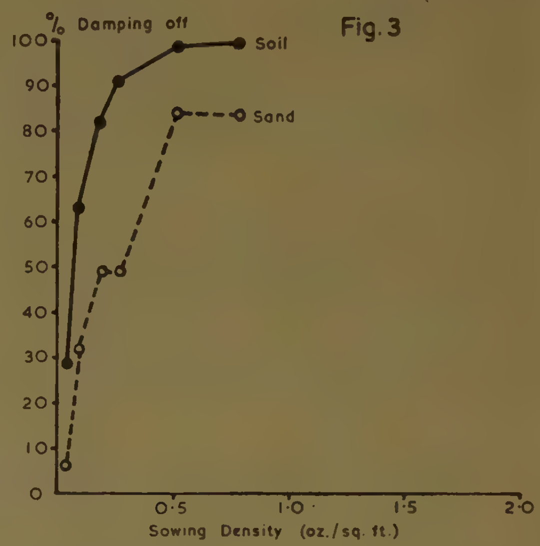
Linear growth of mycelium (mm.)	Agar Medium			
	Soil only	Soil plus 8 seeds per tube	Soil plus 20 seeds per tube	Soil plus 40 seeds per tube
After 2 days	0·7	0·7	0·8	0·9
After 4 days	0·8	3·3	3·5	4·2

Each treatment replicated five times.

Soil Competition

The effect of competition from other members of the soil microflora on the spread of *R. solani*, and the possibility that the rate of spread of damping-off could be modified through this factor by variations in sowing density, has only been investigated indirectly. Attempts have been made to compare the variation of damping-off within ranges of sowing densities in sterile and normal soils, but these have been unsuccessful due to the rapid reinfestation of sterile soil in the glasshouse.

An approach to this type of experiment has been made by comparing the relationship between damping-off and sowing density in plots of sand or soil. This experiment was sown with a range of six sowing densities, replicated three times each in sand and soil. A 10 per cent mixture of sand culture of *R. solani* in soil was used as inoculum, applied at 50 gm. per plot. Results for disease incidence are given in Fig. 3, and Table V gives



further information on the chemical and biological status of the sand and soil used. Chemical analysis was performed by Mr. M. T. Friend, and counts for fungi and bacteria were obtained by plating out a 1:5000 suspension of soil or sand in sterile saline, using a Czapek-Dox agar medium with additional yeast extract (0.05 per cent).

TABLE V.—ANALYSIS OF SAND AND SOIL AND RESULTS OF PLATING FOR COUNTS OF FUNGI AND BACTERIA

	% Nitrogen	% Carbon	C:N ratio	Total phosphate p.p.m.	pH	Colonies per gram soil	
						Fungi	Bacteria
Soil	0·635	5·43	8·55	105	6·6	80×10^3	110×10^3
Sand	0·005	0·11	22·00	0	7·5	34×10^3	$4{\cdot}5\times10^3$

The results show that the greatest incidence of damping-off occurred in the soil with the higher nutrient status and fungal and bacterial population; this would not be expected if competitive rather than nutritional factors modified the rate of spread of the pathogen.

Further evidence has been obtained from a comparison of the relation between sowing density and damping-off in *P. patula* and *P. radiata*. The seedlings of both these species have been found equally susceptible to attack by *R. solani* under comparable conditions in sterile sand. As the seeds of *P. radiata* (33 per gram) are about four times as large as those of *P. patula* (125 per gram), for the same mass of seeds sown per unit area, there will be

fewer seeds and a greater distance between seeds of *P. radiata* than those of *P. patula*. If the spread of pathogens from one seedling to another is limited by activity of the soil microflora, then the relationships between sowing density and damping-off for *P. patula* and *P. radiata*, under comparable conditions, will be coincident when plotted on a basis of numbers of seeds per unit area. However, if the nutrient available to the pathogen be a limiting factor, then these relationships would be expected to be coincident when plotted on a basis of mass of seeds per unit area. The results of two experiments to compare the two pine species in these ways are plotted in Fig. 4. Both sets of results show a coincidence of curves for damping-off when sowing density has been plotted as mass of seeds per unit area, which would be expected if the spread of the pathogen was limited by available nutrient rather than competition from other members of the soil microflora.

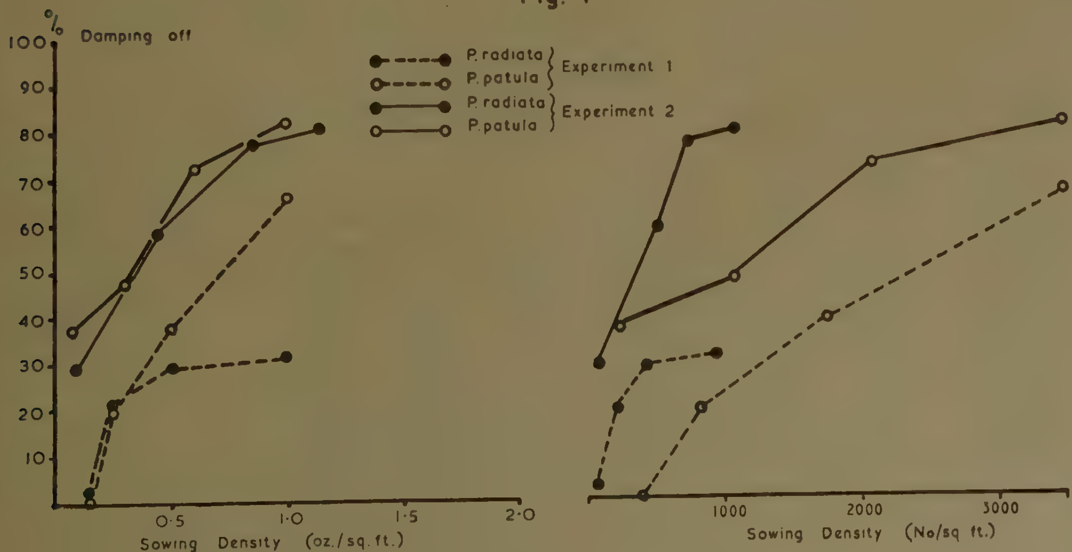
A third experiment has also given results showing that the spread of *R. solani* as a damping-off pathogen is largely dependent on available nutrient. In this the disease incidence over a range of four sowing densities was compared after various mixtures (10, 40 and 80 per cent) of a sand culture of *R. solani* and soil had been applied as inoculum (50 gm. per plot). The results (Table VI) show that where inoculum has been added to plots, a marked gradient of disease with sowing density has been obtained, irrespective of the constitution of the inoculum. The mean values for disease incidence at the three inoculum levels fall within a small range of each other.

TABLE VI.—THE EFFECT OF VARYING QUANTITIES OF INOCULUM OF *R. solani* ON THE RELATIONSHIP BETWEEN DAMPING-OFF AND SOWING DENSITY OF *P. patula*

Sowing Density per sq. ft.		Damping-off (per cent)				
		Per cent composition of added inoculum				Mean
Oz.	No.	0	10	40	80	
0·041	180	0	4·5	12·3	25·9	10·7
0·220	771	21·5	58·0	68·9	53·6	50·5
0·366	1285	33·4	77·3	73·1	75·6	64·8
0·686	2056	6·9	80·4	92·8	86·6	66·7
Mean ..	—	15·4	55·1	61·8	60·4	—

If competition from other members of the soil microflora influenced the rate of spread of the pathogen, then this effect would be overwhelmed by graded increases in inoculum with accompanying increases in mean disease incidence. Similarly, the gradient of disease incidence with sowing density would disappear at high inoculum levels. On the other hand, if nutrient as seeds and seedlings is a major factor in determining the rate of spread of the pathogen, then a gradient of disease with sowing density would be expected irrespective of inoculum level and the mean disease incidence at all inoculum levels would be expected

Fig. 4



to be about the same. On this basis the results show that available nutrient is clearly the major factor in determining activity of the pathogen in relation to sowing density.

Conclusion

Throughout these experiments results have consistently shown that the activity of *R. solani* as a damping-off pathogen is largely dependent on the nutrient available in the soil. Furthermore, increased damping-off losses regularly associated with high rates of sowing have been shown to be due to accompanying increases of nutrient in the soil rather than to any modification of soil moisture conditions or to changes in the degree of competition to the spread of the pathogen through the soil.

The demonstration that dead seeds in the soil may act as nutrient sources for *R. solani* and lead to an increased spread of the pathogen has a practical application. Seeds of low germination are sometimes thickly sown in the bed to obtain reasonable emergent populations. Providing the dead seeds in such defective batches are not empty shells, this practice will lead to an increase in soil nutrient and an increase in the risk of damping-off from *R. solani*.

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MUNINGA (PTEROCARPUS ANGOLENSIS D.C.) IN THE WESTERN PROVINCE OF TANGANYIKA

II—Growth and Form Statistics

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This part is intended for the analysis of enumeration and growth statistics. In all, a total area of 330,000 acres has been enumerated using 1 per cent or 2 per cent surveys. The sites of the surveys have been selected from as wide a range in the Western Province as has been possible. The figures can be taken to represent a very general picture of the forest, except for the Itigi thicket areas. Measurements of height and girth and ring counts have been collected from the Tabora district.

Existing Growing Stock and its Distribution

The Province should rightly be divided into the exploited and the unexploited areas. Unfortunately, it is almost impossible to separate the two types on the ground, but in general the former areas are situated mostly along the railway line and main roads to a depth of 20 to 25 miles and cover about 3,000 to 4,000 square miles. A large part of the remainder of the area has been virtually inaccessible from the exploitation point of view until very recent years. Enumeration figures show that muninga may grow more or less gregariously or spread thinly over very large tracts. The areas of densest occurrence are usually limited by the topography of the terrain and adjacent to a good area may be an equally poor one.

Number of Stems per Unit of Area

Miombo, in general, has an average of 50 to 100 stems over 4 in. q.g. at b.h. for all the species covering areas of not less than 10 acres. The isolated acre may have up to 200 stems on it, muninga comprising about 7 per cent to 10 per cent by number of the stems, varying from 2 per cent to 15 per cent. An individual acre may have up to 40 per cent but only one or two such acres occur in a large area. The muninga stems rarely exceed 15 to 20 an acre with individual cases of up to 30. Areas of a square mile or more average 4.5 to 6.5 stems to the acre (all figures denote stems over 4 in. q.g. at b.h.). The areas to the south of the Ugalla river have shown a greater proportion of smaller trees under 12 in. q.g. than the areas to the north, where, in spite of heavier exploitation, a greater proportion of trees over 12 in. q.g. occurs.

Table I shows the results of enumeration surveys, the stems being divided into quarter girth classes.

Table I.—No. of Trees an Acre in Q.G. Classes (Measured at B.H.)

Area	4–6″	6–8″	8–10″	10–12″	12–14″	14″ and over	Total	Area Enumerated
								acres
Mpanda A–D	3·70	1·92	0·58	0·17	0·05	0·03	6·45	90,500
Nyonga	3·00	1·70	0·60	0·10	0·03	0·03	5·46	2,600
Kaliua–Ugalla A–D ..	3·04	1·06	0·40	0·13	0·10	0·05	4·78	63,200
Urambo	2·43	1·54	0·77	0·28	0·30	0·05	5·37	22,000
Kigwa	2·90	1·10	0·30	0·20	0·30	—	4·80	2,100
Koga	0·96	0·62	0·28	0·10	0·08	0·09	2·13	25,000
Issuri	0·17	0·32	0·36	0·33	0·27	0·28	1·68	24,500
Kakoma	2·56	2·38	1·26	0·49	0·20	0·20	7·09	8,000
Kitunda (*a*)	1·57	1·78	0·66	0·30	0·18	0·06	4·55	19,200
(*b*)	0·48	0·50	0·43	0·25	0·06	0·05	1·77	9,600
Manalede	0·83	0·84	0·63	0·41	0·24	0·28	3·23	24,000
Ugalla F.R.	1·33	1·00	0·53	0·22	0·09	0·06	3·23	24,000
Lyela	0·61	0·29	0·18	0·14	0·12	0·18	1·52	20,300
Average ..	2·22	1·23	0·51	0·21	0·13	0·09	4·39	335,000 acres (Compensated by area)

TABLE II.—VOLUME OF TREES PER UNIT OF AREA

The volume of the different girth classes has been assessed from sample trees and are as follows:—

Area	4–6″	6–8″	8–10″	10–12″	12–14″	14″ and over	Total	Area Enumerated
								acres
Mpanda A–D	6·49	7·17	3·84	1·77	0·67	0·52	20·46	90,500
Nyonga	5·16	6·19	3·80	1·28	0·45	0·59	17·47	2,600
Kaliua–Ugalla A–D ..	5·58	4·60	3·55	1·42	1·56	0·75	17·46	63,200
Urambo	3·60	5·10	4·04	1·88	3·30	1·53	19·45	22,000
Kigwa	4·99	4·11	2·01	2·42	0·43	—	13·96	2,100
Koga	2·12	2·34	1·97	1·06	1·00	1·63	10·12	25,000
Issuri	0·34	1·09	2·21	3·05	3·32	4·50	14·51	34,500
Kakoma	4·48	8·86	8·50	4·96	2·77	3·64	33·21	8,000
Manalede	1·73	3·01	4·18	4·15	3·01	4·71	20·79	24,000
Average ..	4·35	4·84	3·56	2·10	1·72	1·72	18·29	271,900 acres (Compensated by area)

The total volume of trees over 4 in. q.g. b.h. varies between 5 and 45 cu. ft. an acre for areas not less than 20 acres. By weighting the areas of enumeration survey against the figures obtained the average is 20.5 cu. ft. approx. From these statistics it would seem that the volume per acre is much more stable than the number of trees per acre and it could be assumed that 20 cu. ft. an acre is the average capacity of this woodland in its present state.

As would be expected, the areas north of the Ugalla river have a larger volume in the upper girth classes owing to the larger number of trees. Similarly, the Mpanda and Nyonga areas have larger volumes in these smaller girth classes. It would be natural to expect a larger volume in the 4–6 in. class than in the 6–8 in. This is not the case and may be the result of exploitation of building poles, etc.

Distribution of Quality Classes

The enumeration surveys indicate that the woodlands carry a fairly even distribution of muninga over considerable areas. It has, however, been decided for this report to divide the woodland into three categories or quality classes not according to their total volume but instead, according to the volume of exploitable mature trees over 15 in. q.g. b.h. The range of timber volume is from 0 to 1.25 cu. ft. an acre and the classes have been decided as follows:—

Class 1 over 1.0 cu. ft. per acre.

Class 2 0.5 to 1.0 cu. ft. per acre.

Class 3 0 to 0.5 cu. ft. per acre.

This division corresponds approximately to over 20, 10 to 20 and 0 to 10 mature trees an acre inclusive of defective trees.

Class 1.—This includes all the best muninga areas which are generally found as isolated patches rarely more than 10 square miles in extent and are overmature or mature forest for this species. Some of these areas have been previously exploited but still contain sufficient exploitable or nearly exploitable timber to merit being placed in this class. These good patches may occur over a large area in patchwork form. Such areas have been found at Mabama–Usoke, Malongwe–Tura Usagari–Ichemba, Ngoywa–Kakoma, Rungwa, Kasanga and Lyela.

Class 2.—This is what one might call second-best areas and are probably forests just reaching maturity and in a condition similar to what one might get with controlled exploitation by area. As a forest type it is more widespread than Class 1 and occurs in large-size patches throughout areas north of the Ugalla river and between Nyonga and Rungwa and the Lupa road. It is found again at Sitalike–Kipapa and in the area west of Bukene.

Class 3.—This forest has the appearance of being immature. This, in many cases, may be an illusion, but over large areas it is probably correct to say that muninga is a new and immature crop. A large block of such forest occurs to the east of Mpanda.

The extent of the areas covered by each class is not known to any degree of exactness and can only be assessed from visual observation in conjunction with enumeration survey. From observation, the following division is made:—

	Sq. miles
Class 1	2,000
Class 2	7,500
Class 3	23,000
Unproductive mbuga, settlement and grassland ..	2,500
Total ..	35,000

This is not the whole of the Province but merely the assessed miombo woodland area.

Statistics of Increment and Growth

The statistics used in this section are derived mainly from the measurements of the Ichemba increment plots and from a random selection of butt-ends of logs from Issuri Sawmill near Malongwe. The statements made may cause controversy but in view of the lack of other evidence these figures are considered to be satisfactory. If they lead to the production of other figures of equal or better reliability they can do nothing but good; and our knowledge will be increased thereby. A point which should be made here is that ring counts are not a satisfactory means of assessing the age of a tree with our present limited knowledge and also the butt-end and breast height measurements do not cater for the growth of the tree from a seedling to a shoot of 1½–2 ft. high, a stage of growth which may take a short or a long time. One report to hand states that a 9-in. shoot showed on its carroty rootstock 130 rings! It seems very difficult to believe that these are annual rings or even half annual rings.

Girth Ichemba Increment Plot Statistics

Measurements of breast-height girth took place after an interval of 18 years from the initial laying down of the plot. A total of 279 stems were remeasured of which 18 were either not measured at breast height or were not traceable. The annual percentage increment (based on final girths) varied from 0 to 3.67 per cent and averaged 0.9 per cent for the whole plot. Actual annual girth increment varied from 0 to 0.96 in. and averaged 0.298 in. for a tree of 31 in. girth (excluding trees which had died during the past 18 years) and 0.272 in. for a tree of 30-in. girth inclusive of dead trees.

Two methods have been used to arrive at figures for the growth of dominant trees only, in one method the one-third of the total trees which showed the fastest growth have been selected to represent the dominant trees, in the other, the trees which have appeared visually in the field to be dominant trees by virtue of having reached the general level of the upper canopy or beyond it have been used for comparison with the first. Table III has been complied from the results.

Table III.—First Method

(*Fastest growing trees*)

1949 Girth Class	No. of Stems	Av. Girth in 1931	Av. Girth in 1949	Av. Incrmt. in 18 years	Av. Incrmt. % per annum
in.		*in.*	*in.*	*in.*	
0–8	1	3¾	6	2¼	2·08
8–16	8	8⅛	12¼	4⅛	1·93
16–24	14	14¼	20⅝	6⅜	1·72
24–32	23	20⅜	28⅞	8½	1·63
32–40	24	25¾	36½	10¾	1·62
40–48	6	34¾	45⅝	10⅞	1·33
48–56	5	37⅜	51¾	14	1·51
56–64	—	—	—	—	—
64–72	—	—	—	—	—
72–80	—	—	—	—	—
Total ..	81	21⅝	30⅜	8¾	1·65

SECOND METHOD

(*Dominant trees*)

1949 Girth Class	No. of Stems	Av. Girth in 1931	Av. Girth in 1949	Av. Incrmt. over 18 years	Av. Incrmt. % per annum
in.		*in.*	*in.*	*in.*	
0–8	—	—	—	—	—
8–16	—	—	—	—	—
16–24	1	18½	22¼	3¾	0·93
24–32	17	24⅛	29⅜	5¼	0·99
32–40	31	29⅜	36⅜	7	1·06
40–48	16	36⅝	44⅜	7¾	0·96
48–56	13	42½	51¼	8¾	0·94
56–64	5	48½	58¾	10¼	0·98
64–72	—	—	—	—	—
72–80	1	71½	79½	8	0·56
TOTAL	84	33⅜	40⅝	7¼	1·00

It is apparent that there is a difference between fast-growing trees and dominant ones. In the two groups only ⅜–½ of the trees are common to both. It is suggested that the method of choosing fast-growing trees tends to select trees which would become the dominants over a long period, e.g. a full rotation or nearly so, whereas the method of choosing visual dominants tends to select those trees which will form the dominants of the crop during the next felling cycle say equal to a third of the rotation. Furthermore, this second method tends to be more accurate than the former since all the trees have reached the upper canopy and are less liable to factors which would reduce their form or rates of growth.

From the statistics in Table III two graphs can be constructed showing the rates of growth of each girth class, e.g. in 32–40-in. class the average tree grows from 25¾ in. to 36½ in. over a period of 18 years. When these classes are put together a graph of age and girth is obtained. The results in Table IV have been obtained from the two methods used in Table III.

TABLE IV

FIRST METHOD (FASTEST GROWING TREES)			SECOND METHOD (DOMINANT TREES)		
Girth Class	Age	Length of Period	Girth Class	Age	Length of Period
in.	*years*	*years*	*in.*	*years*	*years*
(0–8	0–33	33)	(0–8	0–30	30)
8–16	33–66	33	(8–16	30–60	30)
16–24	66–87	21	16–24	60–89	29
24–32	87–102	15	24–32	89–113	24
32–40	102–116	14	32–40	113–133	20
40–48	116–128	12	40–48	133–150	17
48–56	128–140	12	48–56	150–166	16
(56–64	140–151	11)	56–64	166–184	18
(64–72	151–161	10)	(64–72	184–200	16)
	—	—	(72–80	200–217	17)

Brackets show that there are not sufficient trees to form a reasonable average.

From these two tables we get firstly the capabilities of the species under free growth, i.e. under good silvicultural conditions, and secondly the state of progress of the dominant trees of the forest at the present time. Neither table is very valuable in both the highest and lowest classes due to insufficient numbers of trees. Of these classes the lowest 0–8 in. is of most importance owing to the uncertain circumstances attached to germination and early growth. This class is, however, dealt with more fully under stem form below.

Ring Counts from Butt-ends of Logs.—Ring counts are difficult and not completely satisfactory even when carried out with the help of a lens. Long lines of parenchyma appear throughout the cross-section and the final selection of rings which indicate the end of the season's growth cannot always be determined with certainty more especially in the lower parts of the stem and underground and also in the sapwood as compared with the heartwood. A continuous band of parenchyma often appears to have formed during the break in the rains and again apparent end-of-the-seasons rings can be traced round and found to fade out. These latter are probably "false" rings and should be excluded.

For ring counts only ten cross-sections of logs were used. Statistically, this number is insufficient and further data should be collected. The exact significance of a ring in terms of growth seasons is not yet proven, but it is believed that only one real ring is put on annually, while false rings may occur as the result of breaks in the rain or through bush fires destroying the foliage.

Table V shows the number of rings along the average of four radii for ten trees measured.

On comparison with the statistics in Table IV it would seem feasible to suggest that the tree puts on one ring every two years. This has, of course, no support except statistical data and a larger number of butt-ends would need to be counted to make the comparison of better value. As it is, six of the Ichemba trees were growing at the rate of approximately 1-in. girth a year or 60-in. girth in 60 years and also one Issuri butt-end showed approximately 140 rings for a girth of 60 in. In this way it could be argued that most of the trees selected for felling at Issuri are only the faster-growing dominants and that only one ring is put on annually.

It should be noted that these ring-counts apply to trees at approximately 2 ft. above ground level, in other words after they have become established. While drafting this report a further investigation was carried out on 20 small trees. Sections were taken at breast height, ground level and underground on the main root. The object of the investigation was to compare the numbers of rings at each level. The results show that there is a difference of 0–3 rings between ground level and breast height excluding two exceptional results of five and eight rings. The average of all sections was 1.9 rings. There was a marked difference between ground level and 6–9 in. underground

TABLE V

(*All figures in inches except where otherwise stated*)

Radius in inches	1	2	3	4	5	6	7	8	9	10
Circumference at 2 ft. from ground under bark	6·28	12·57	18·85	25·33	31·42	37·70	44·18	50·66	56·65	62·83
Taper factor	·90 for all radii									
Circumference at b.h. under bark	5·65	11·31	16·96	22·90	28·28	33·63	39·76	45·59	50·98	56·55
Circumference at b.h. over bark to ⅛ in.	7	14	19¾	25¾	31⅛	36⅜	43⅛	49⅜	55¼	61¼
Factor for o.b. Movements *add*	¼	1/5	1/6	⅛	1/10	1/12	1/12	1/12	1/12	1/12
No. of rings	11·0	20·7	28·5	35·5	43·0	50·3	58·2	66·5	72·2	80·4

and results varied from 0–14 rings with an average 7.0–7.6 rings. The rings on root sections are much more difficult to determine and in some cases accuracy to one ring was impossible; also it was impossible to fix an exact level at which the measurement should be taken owing to the shapes of the root systems. The ring measurements are recorded in Table VI.

Table VI shows that basal growth for the first 12 years is more rapid at ground level than at breast height. Similarly the bark at the base of the tree grows faster than that at breast height and this may be related to self-protection against fire.

In order to obtain useful field data the above figures need to be converted from inches along radii to inches of girth over bark. It has been found that the average measurement over bark along the radii when converted to circular measurement falls short of the measurements of tree girth made in the field. This is due to three causes, firstly the radii do not always reach points on the outer bark similar to those points touched by a girthing tape, and the average radius results in a figure which reaches approximately half-way between outermost and innermost surfaces of the outer bark; secondly, there are margins of error caused by measuring four radii at right angles; and thirdly, sections measured for girth were freshly felled while radial measurements took place after the sections had been planed and kept for some time allowing shrinkage to take place. Figures for overbark measurement in Table VII are given in the full knowledge that there are not sufficient numbers of measurements to support the statements. They are, however, within reasonable limits.

In comparison with the Issuri butt-end figures and the Ichemba Increment Plot figures it will be seen that a tree of 8-in. girth at breast height (or 1.15 radius) is 12 years old (Issuri), 30–33 years old (Ichemba) or 16½ years old in the above table (assuming one ring a year). It is obvious that the great difference between increment measurements and ring counting needs further investigation, firstly, by determining exactly the significance of a ring and the time taken to move from one to another and also by periodic measurement of a large number of trees under 8-in girth. Already both of these investigations have been started.

TABLE VI.—AVERAGE DISTANCE IN INCHES ALONG AVERAGE RADIUS

Ring No.	1	2	3	4	5	6	7	8	9
At B height	·144	·238	·308	·381	·436	·484	·526	·553	·601
At ground level	·188	·315	·410	·498	·569	·622	·677	·704	·739
Ring No.	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
At B height	·655	(·815)	(·877)	(·957)	(1·01)	(·995)	(1·055)	—	—
At ground level	·790	·830	·895	·960	1·01	1·08	1·133	1·190	1·263

Bracketed figures indicate insufficient numbers of trees available for reasonable average.

TABLE VII.—TABLE OF AVERAGE GIRTHS OVER-BARK IN INCHES IN RELATION TO NUMBER OF RINGS

Ring No.	1	2	3	4	5	6	7	8	9
At B height	1·45	2·30	2·95	3·55	4·05	4·50	4·90	5·20	5·55
At ground level	1·55	2·65	3·60	4·45	5·15	5·80	6·35	6·90	7·35
Ring No.	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
At B height	5·85	6·20	6·55	6·90	7·20	7·50	7·80	8·15	8·50
At ground level	7·75	8·15	8·55	8·95	9·35	9·75	10·15	10·55	10·95

The Conservator of Forests, Northern Rhodesia, stated in 1951 that 15 trees of known seed origin sown in 1933 have reached breast height girths of 7 in. to 16 in. The average of all stems is 11.6 in. (four trees have double stems).

Height

Most of the data for this section comes from the Ichemba Plot measurements. The method used in 1931 was, it is believed, very similar to that used in 1949, that is, by using a graduated 10-ft. pole and estimating the number of times that it was required to reach the height of the tree. Two types of height were measured, total height, being the vertical height to the top of the foliage or twigs of the tree, and timber height, being the height to the first large branch, fork or bend.

Two methods of calculation have been used for comparison. These are the methods used for girth increment (Foggie's method), and the method of using visual dominants and constructing a graph of the results. Since the measurements of 1931 and 1949 show differences which indicate insufficient accuracy in the method of measurement used, it has been necessary to use the time/girth graphs to rectify the results derived from height measurements only.

Total Height.—By Foggie's method a curved graph has been obtained which shows up to 90 years a regular decreasing growth rate, after an initial rapid start, and then an increasing growth rate. This graph suggests reasonably quick growth, decreasing as the crown nears the general level of the canopy but increasing again as the tree becomes predominant and more or less free growing. The relationship of age, of age/girth and age/height compare favourably up to the age of 90 years but differences then appear which might be due to insufficiency in the number of trees measured. Table VIII has been compiled from the graph.

Using the method of graphing the visual dominants most of the data is confined to trees of 90–160 years old and there as a large gap from 0–90 years with insufficient data except to suggest a vague curve. A curve has been constructed tentatively suggesting possible rate of growth. This curve varies from that obtained by Foggie's method by being regular throughout without any suggestion of a change at 90 years old. The figures in Table IX can be graphed.

TABLE VIII.—RELATIONSHIP OF HEIGHT/AGE OF DOMINANT TREES—FOGGIE'S METHOD (BY PER CENT INCREMENT.)

(A) Age (years)		(10)	(20)	30	40	50	60	70	80
Total height (feet) ..		(10·0)	(14·0)	(16·9)	19·2	21·3	23·5	25·6	27·6
Age (years)		90	100	110	120	130	140	150	160
Total height (feet) ..		29·6	31·5	33·5	35·8	38·5	40·6	42·8	45·1
(B) Total height (feet)	5	10	15	20	25	30	35	40	45
Age (years) ..	3½	10	23	43	67½	92½	117	138	(159)

TABLE IX.—RELATIONSHIP OF HEIGHT/AGE OF VISUALLY DOMINANT TREES

(A) Age (years)	10	20	30	40	50	60	70	80	90
Total height (feet)	(6·6)	(11·2)	(15·2)	(19·0)	(22·2)	(24·9)	(27·3)	(29·5)	(31·5)
Age (years) ..	100	110	120	130	140	150	160		
Total height (feet)	33·2	34·9	36·2	37·5	38·9	40·3	—		
(B) Total height (feet)	5	10	15	20	25	30	35	40	45
Age (years) ..	7	17	29	43	60	82½	111	148	?

The 20 small trees felled for ring counts at Simbo were measured for total height and a rough graph constructed, yielding Table X.

The Northern Rhodesian report shows the average height of 15 trees originating from seed as 26.2 feet after 17 years' growth. This is much faster than is indicated by either of the tables above.

Timber Height.—It has been considered from observations in the forest that muninga quickly reaches its rather low timber height. This is more or less confirmed by the graphs which have been constructed. Such deformities as serious kinks, broken tops, forks, etc., usually define the timber height which may be reached by the 30th year. It seems very possible that pruning would increase the timber height by 20 to 40 per cent. If this silvicultural operation is performed at the right season of the year, the pruned branches might be planted at wide spacing in the surrounding forest and thus increase the stocking of seed-bearer trees if not of timber trees.

An experiment laid down in Simbo Forest Reserve to determine the results of pruning has already shown that the initial pruning increased the potential timber lengths of the crop by 20 to 25 per cent. These plots are laid down in regrowth after tsetse clearing.

Graphs drawn from available data fail to cover accurately the initial growth from 0–25 years. Data is obtainable as in Table XI.

TABLE X

(A) No. of rings at b.h. ..		1	2	3	4	5	6	7	8	9	10
Total height (feet)		4·7	6·0	9·0	10·8	12·2	13·3	14·4	15·2	16·0	16·8
No. of rings at b.h.		11	12	13	14	15	16				
Total height (feet)		17·6	18·5	19·3	20·1	20·9	21·5				
(B) Total height (feet)	2	4	6	8	10	12	14	16	18	20	22
No. of rings at b.h. ..	·4	·8	1·6	2·5	3·5	4·9	6·8	9·0	11·3	13·8	(17·6)

TABLE XI.—TIMBER HEIGHT/AGE RELATIONSHIP OF DOMINANT TREES

(*Foggie's Method*)

N.B.—Heights shown are to the lowest large branch.

(A) Timber height	6	8	10	12
Age (years ..	(17)	(23)	(29)	35
Timber height ..	14	16	18	20
Age (years) ..	44	60	95	160
(B) Age (years) ..	10	20	30	40
Timber height ..	(3·5)	(7·0)	(10·5)	13·2
Age (years) ..	50	60	70	80
Timber height ..	14·9	16·0	16·7	17·4
	90	100	110	120
Timber height ..	17·8	18·2	18·7	19·1
Age (years) ..	130	140	150	
Timber height ..	19·3	19·5	19·7	

The graphs of visually dominant trees have not been translated into a similar table. They indicate that most trees have reached their maximum timber height before 70 years at an average of 19 ft. No appreciable increases are recorded thereafter.

From the data given above it can be assumed that a timber height of 13 to 20 ft. applies to the greater proportion of trees after early life. The height is reached at an early age of about 50 years and comprises about 70 per cent of the total height of the tree. From this stage onwards the crown increases in height but the timber height is static. The ultimate proportion of timber to total height in old age is 30 to 40 per cent.

Statistics exist showing the relationship of timber height to breast height girth. The figures in Table XII are taken from enumeration survey sample trees.

TABLE XII.—TIMBER HEIGHTS IN FEET IN RELATION TO GIRTH CLASSES

Area	Girth Classes in Inches at B.H.					
	4–6	6–8	8–10	10–12	12–14	Over 14
Mpanda A–C	11·07	12·78	13·32	13·4	14·5	—
Mpanda D	8·78	11·27	10·00	9·16	17·00	—
Kaliwa A–F	—	12·60	13·36	13·65	13·85	—
Koga (South)	13·75	11·65	15·8	—	—	—
Koga (North)	12·64	12·23	12·05	12·50	12·34	12·38
Kakoma	—	—	—	13·4	12·66	13·54
Issuri	—	11·80	11·90	11·62	12·19	11·66
Kitunda	—	—	—	12·64	11·56	15·68
Compensated Average	10·66	12·17	12·92	13·01	12·56	12·90
No. of Trees measured	157	198	243	293	244	109

These figures indicate that the Ichemba figures are for exceptionally good forest and that the average timber heights vary between 10 and 15 ft.

Stem Form

The only measurements examined are those taken at Ichemba and a series of breast height/mid-girth and stump/mid-girth measurements taken in Tabora district generally.

The Ichemba figures (Tables XIII and XIV) give the relationship of girths at ground level and at breast height to girths at one foot intervals from 1 ft. to 6 ft. above ground as a percentage of the former.

TABLE XIII.—RELATION TO GROUND LEVEL

B.H. Girth Class (in.)	Percentage of Ground Level Girth at						
	1 ft.	2 ft.	3 ft.	4 ft.	4 ft. 6 in.	5 ft.	6 ft.
0–12	89·6	79·9	75·5	71·5	70·0	68·2	64·9
12–24	92·3	87·9	83·5	79·9	78·5	77·2	75·8
24–36	92·8	88·5	85·6	82·7	81·2	79·7	78·6
36–48	92·0	88·8	86·4	84·4	83·2	82·0	80·5
48–60	89·5	86·2	85·6	82·6	80·3	80·0	79·2
Over 60	93	89	86·8	85	84	83	81·2

TABLE XIV.—RELATION TO BREAST HEIGHT

B.H. Girth Class (in.)	Percentage of Breast Height Girth at (Additional Figures by Graph)						
	Ground level	3 ft.	4 ft.	5 ft.	6 ft.	7 ft.	8 ft.
0–12	143	108	102·1	97·4	92·7	87·3	83·6
12–24	117	106·2	101·5	98·2	96·6	94·3	92·5
24–36	114	105·2	101·7	98·2	96·8	94·2	92·4
36–48	110·5	103·7	101·3	98·6	96·8	94·3	92·3
48–60	110	105·3	101·4	98·6	97·5	94·5	92·0
Over 60	110	104	101·1	98·7	96·8	94·3	92·0

The greater taper is in 0–12 in. class trees, above 12 in. there is very little change in girth differential. This would be expected if a 12-in. tree had reached the main canopy and completed its height growth. Increment would be put on evenly all along the timber stem. A further point of considerable value is that the breast height/mid-log girths for mature trees up to 16 ft. log length vary only by up to 10 per cent. Taper above breast height seems fairly constant at 2–2½ per cent for each foot of log.

The mid-log/stump girth relationship has been calculated for 300 logs of stump girths from 4 ft. to 6 ft. 6 in. with the results given in Table XV.

If stump height is taken as 1 ft. above ground these figures compare favourably with Table XIII.

Volume Per Tree

Volumes of individual stems and logs have been calculated mainly by the formula ($\frac{1}{4}$ mid-girth)^2 x length. For standing trees the mid-girth has been obtained by applying a form factor to the breast height girth (factors derived from Tables XIII to XV and other measurements). All volumes are over bark unless otherwise stated. The Ichemba statistics give the volumes per tree shown in Table XVI, derived from the age/girth classes.

TABLE XV

Stump girth	Av. stump girth		Av. mid girth		Av. log length	Per cent mid girth/stump
	ft.	*in.*	*ft.*	*in.*	*ft.*	*per cent*
4 ft. to 4 ft. 5 in.	4	2·5	4	0	11·4	95
4 ft. 6 in. to 4 ft. 11 in.	4	9·3	4	2·8	12·8	88½
5 ft. to 5 ft. 5 in.	5	1·8	4	8·0	14·5	90½
5 ft. 6 in. to 5 ft. 11 in.	5	7·8	4	8·5	14·3	83¼
6 ft. to 6 ft. 6 in.	6	2·8	4	9·1	16·0	76½

TABLE XVI

Age in years	VOLUME, HOPPUS, FT.		TRUE VOLUME	
	Foggie's Method	Vis. Dom. Method	Foggie's Method	Vis. Dom. Method
10	·009	·013	·012	·017
20	·069	·083	·088	·106
30	·200	·238	·255	·304
40	·413	·491	·527	·627
50	·684	·889	·873	1·134
60	1·075	1·451	1·372	1·852
70	1·739	2·055	2·219	2·623
80	2·635	2·852	3·362	3·639
90	3·867	3·712	4·936	4·737
100	5·91	4·747	7·541	6·057
110	8·40	5·885	10·722	7·511
120	11·50	7·510	14·682	9·583
130	15·39	9·332	19·63	11·91
140	20·02	11·504	25·55	14·68
150	25·53	14·420	32·58	18·17
160	32·30	16·897	41·22	21·57
170	—	20·588	—	26·28
180	—	24·201	—	30·88

These figures can be translated into girthclass trees and compared with sample trees from enumeration survey figures as in Table XVII.

TABLE XVII

Locality	Quarter Girth in Inches														
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Mpanda A–C	1·0	1·84	2·85	4·00	5·35	6·65	7·80	9·05	10·65	12·30	13·95	15·55			
Mpanda D	0·9	1·45	2·65	3·75	4·60	5·55	6·60	7·75	9·80	11·85	13·95	16·0			
Kaliwa Ugalla	1·0	1·75	2·80	3·85	5·25	6·65	7·65	9·05	11·05	13·17	15·20	17·30			
Koga (South)	1·65	2·10	2·70	3·75	5·10	6·70	8·30	10·05	11·80	13·45	15·05	17·05	19·70	22·3	24·9
Koga (North)	1·25	1·90	2·80	3·75	5·20	6·65	8·55	10·45	12·00	13·50	15·40	17·20	18·75	21·1	23·0
Kakoma	—	—	—	—	—	6·8	8·35	10·00	11·55	13·40	16·20	18·50	22·10	25·25	28·5
Issuri	1·0	1·90	2·80	3·85	5·10	6·40	7·90	9·35	11·05	12·90	15·00	17·15	19·40	21·55	23·75
Kitunda	—	—	—	—	—	6·50	8·00	9·55	11·15	13·20	16·50	19·70	23·00		
Average	1·13	1·82	2·77	3·83	5·10	6·49	7·89	9·41	11·13	12·97	15·16	17·31	20·59	22·55	25·04
cf. Ichemba	1·58	2·40	3·5	4·8	6·4	8·1	10·15	12·4	14·8	17·4	20·0	23·2	26·5	30·1	33·6

The Ichemba timber heights are from 10 to 50 per cent greater than in the other areas and with this taken into account the samples show a reasonable correlation.

A limit of 5 ft. has been considered as the minimum exploitable breast height girth for many years. The average volume (under bark) of 100,000 logs cut by the two main concessionaires in Western Province, works out at 23.9 Hoppus ft. Over the period 1942 to 1950 the average tree in any one year varied from 21.2 H. ft. to 31.5 H. ft. These trees would be 150 or more years old in most cases and could be considered as mature or over-mature.

Exploitation figures for logs of mid-girth of 3 ft. to 5 ft. have been obtained from areas being cleared of tree growth at Urambo. A sample of 1,500 trees in 4.-in. girth class was examined with the results given in Table XVIII.

TABLE XVIII

Calculated B.H. Class	Mid-Girth Class	Average Mid-Girth	Average Timber length	Average Volume
in.	*in.*	*in.*	*ft.*	*H.ft.*
35–37½	36	36·0	9·15	5·14
37½–41	36–40	39·1	8·98	5·93
41–45	40–44	42·0	9·61	7·36
45–49	44–48	45·6	10·48	9·23
49–53	48–52	50·4	9·85	11·12
53–57	52–56	52·8	9·55	12·09
57–61	56–60	57·6	10·56	14·42

The longest log length shown is 16 ft. and some stems may therefore have been cut into two logs.

A further set of 250 logs varying from 44 in. to 59 in. mid-girth were examined in order to compare with the Urambo figures. These yielded the data in Table XIX.

TABLE XIX

Calculated B.H. Girth	Mid-Girth Class	Average Mid-Girth	Average Timber length	Average Volume
in.	*in.*	*in.*	*ft.*	*H. ft.*
46–50	44–47	45·9	13·40	12·31
50–54	48–51	49·8	13·77	14·87
54–59	52–55	53·5	15·31	19·03
59–64	56–59	57·5	14·35	20·55

The reason for paying special attention to the 3–5 ft. girth class is that in most yield calculation formulæ this class is as important as the trees which will be cut for they represent the immediate replacement.

Field measurements checked with mill-log statistics for 1,311 trees of exploitable size yielded the figures in Table XX.

TABLE XX

B.H. Girth Class	No. of stems measured	Av. Volume per tree
		H.ft.
5 ft. 0 in. to 5 ft. 6 in.	850	20·46
5 ft. 7 in. to 6 ft. 6 in.	340	27·60
6 ft. 7 in. to 7 ft. 6 in.	84	37·69
7 ft. 7 in. to 8 ft. 6 in.	37	50·32

Bark Allowance

A limited amount of information has been obtained from the cross sections of logs used for ring counts, and Table XXI has been prepared from this. More data are required before this table can be used generally.

TABLE XXI

Girth over bark	Deduction for bark	Per cent of o.b. girth
	in.	*per cent*
6 in.	1½	25
12 in.	2	16·6
18 in.	2¼	12·5
24 in.	2½	10·0
30 in.	2½	8·3
Over 30.	1 in 12	8·3

Defects Allowance

No statistical data have been collected. The main reason why millers very often do not ask for logs to be examined for defects is that their headmen have only selected the soundest trees in the woodland. If all sizeable trees were taken the defects would be more noticeable.

Crown/Girth Relationship

A series of measurements of crown diameters and girths at breast height were made at Simbo near Tabora. Analysis of the results show the relationships in Table XXII.

TABLE XXII

Crown Diameter	Girth B.H.
ft.	*in.*
5	5·01
10	11·22
15	18·20
20	25·12
25	33·11
30	40·74
35	47·86
40	56·23
45	66·07

It was found that height only slightly affected the crown diameter/girth relationship, and that as the girth increased so did the crown diameter, but at a faster rate. This information is useful for assessing potentialities of stocking and for analyzing air photo interpretations.

REVIEW

Jute Manufactures

In no post-war year up to 1953-54 was world production of jute manufactures above 1.6 million tons, compared with 1.9 million tons in the immediate pre-war years, according to estimates given in a report issued by the Commonwealth Economic Committee.* International trade in jute goods reflected this decline, the volume of world exports until recently being some 15 per cent less than before the war; in 1954, however, world trade was not far below the pre-war level. On the other hand, as prices have risen sharply, the value of these exports was in 1954 about four times as great as before the war.

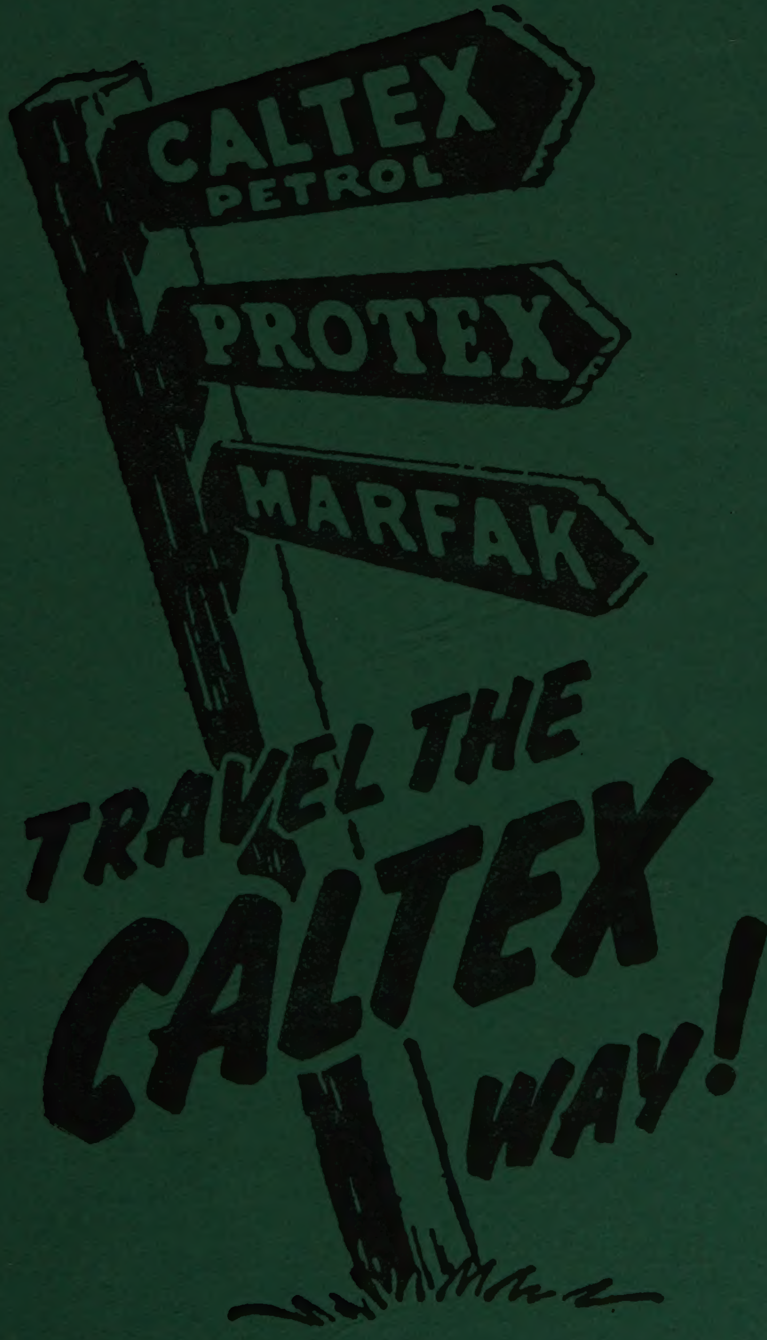
Following a reduction in the area under the crop during the war, there was an acute shortage of raw jute in the early post-war years. As at that time most of the world supply of this commodity was grown in Pakistan while about 70 per cent was utilized by the Indian mill industry at Calcutta (which was also the export outlet) the shortage was accentuated by the dislocation of trade occasioned by the partition of the Indian subcontinent in 1947, and subsequently by the devaluation of the Indian rupee in 1949. By the time these difficulties were eased the intense demand created by the Korean war in 1950–51 had supervened. Heavy sowings in 1950-52 yielded supplies adequate to meet all needs and in fact for a time production exceded demand by a wide margin. In these circumstances it became necessary to restrict production and the 1953-54 crop was only about two-thirds of that for 1952-53.

India continues to be much the largest producer of jute manufactures, providing 55 per cent of the estimated world total, but the average output of the Indian mills for the years 1951-52 to 1953-54 was still some 20 per cent lower than pre-war. On the other hand, Pakistan, formerly a producer of raw jute only, has now established a manufacturing industry, which is scheduled to expand very considerably in the near future. In the United Kingdom, with the increase in raw jute imports since 1950, production has recovered to an appreciable extent although in 1954 it was still about 30 per cent lower than pre-war. Output in continental Europe has regained the pre-war level.

The lower level of trade in jute manufactures in post-war years was attributable to the decline in shipments from India and the United Kingdom. During the years 1951-54 Indian shipments averaged 770,000 tons, 100,000 tons less than in 1934-38 while United Kingdom exports fell by 35,000 tons. As against this, however, the export trade of continental Europe rose by over 40,000 tons to 100,000 tons. There have also been some marked changes in the pattern of trade. India's exports to Commonwealth countries were on the whole fairly well maintained until 1952-53 (despite the cessation of supplies to South Africa) but there was a very sharp fall in shipments to some other countries, particularly Burma, Argentina, Indo-China and Egypt; exports to the dollar area, which were above pre-war levels until 1949, have in general since then been lower than before the war.

The report reviews also the sharp fluctuations in jute prices which have occurred during post-war years. At one time, during the Korean crisis of 1950-51, the price of Indian manufactures was over eight times the pre-war average and even in 1954, when prices were much lower, the value of world exports of jute goods was estimated at £115.000,000 compared with only £26,000,000 in 1938, although the volume of trade was slightly smaller. It is pointed out that price and supply factors have in part been responsible for the development of jute substitutes and that this trend, combined with the expansion of the manufacturing industry, has given rise to a problem of surplus capacity in some cases.

* *Jute Manufactures*. Price 2*s*. 6*d*. (2*s*. 9*d*. post free). Obtainable from H.M. Stationery Office or from the Commonwealth Economic Committee, 2, Queen Anne's Gate Buildings, Dartmouth Street, London, S.W.1.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